

# Anabolic androgenic steroid abuse in the United Kingdom: An update

Carrie Mullen<sup>1</sup> | Benjamin J. Whalley<sup>2</sup> | Fabrizio Schifano<sup>3</sup> | Julien S. Baker<sup>4</sup>

<sup>1</sup>School of Computing, Engineering and Physical Sciences, University of the West of Scotland, Paisley, UK

<sup>2</sup>School of Chemistry, Food and Nutritional Sciences, and Pharmacy, The University of Reading, Reading, UK

<sup>3</sup>School of Life and Medical Sciences, University of Hertfordshire, Hatfield, UK

<sup>4</sup>Centre for Health and Exercise Science Research, Department of Sport, Physical Education and Health, Hong Kong Baptist University, Kowloon Tong, Hong Kong

## Correspondence

Carrie Mullen, School of Computing, Engineering and Physical Sciences, University of the West of Scotland, Paisley PA1 2BE, UK.  
Email: carrie.mullen@uws.ac.uk

Anabolic androgenic steroids (AASs) are prescribed for medical conditions related to low testosterone. Abuse of AASs has surged as they become recognised as potent image enhancement drugs. The primary goal of most abusers is to obtain a more attractive outward appearance. Abuse is complex. There are a vast range of AAS substances illegally available, the nature of their true composition is difficult to evaluate. Users follow dosing patterns which incorporate a number of different AASs, in addition to other pharmaceutical substances believed to complement the desired physical effects or manage unwanted effects. Animal work and medical case reports suggest potential to cause serious hepatotoxicity, plus possible neurotoxicity, nephrotoxicity and damage to the cardiovascular and reproductive systems. As the long-term AAS users reach maturity, further controlled experimentation, with larger sample sizes, is required. Data gathering should be directed towards the most vulnerable group of AAS users, females and adolescent boys.

## 1 | INTRODUCTION

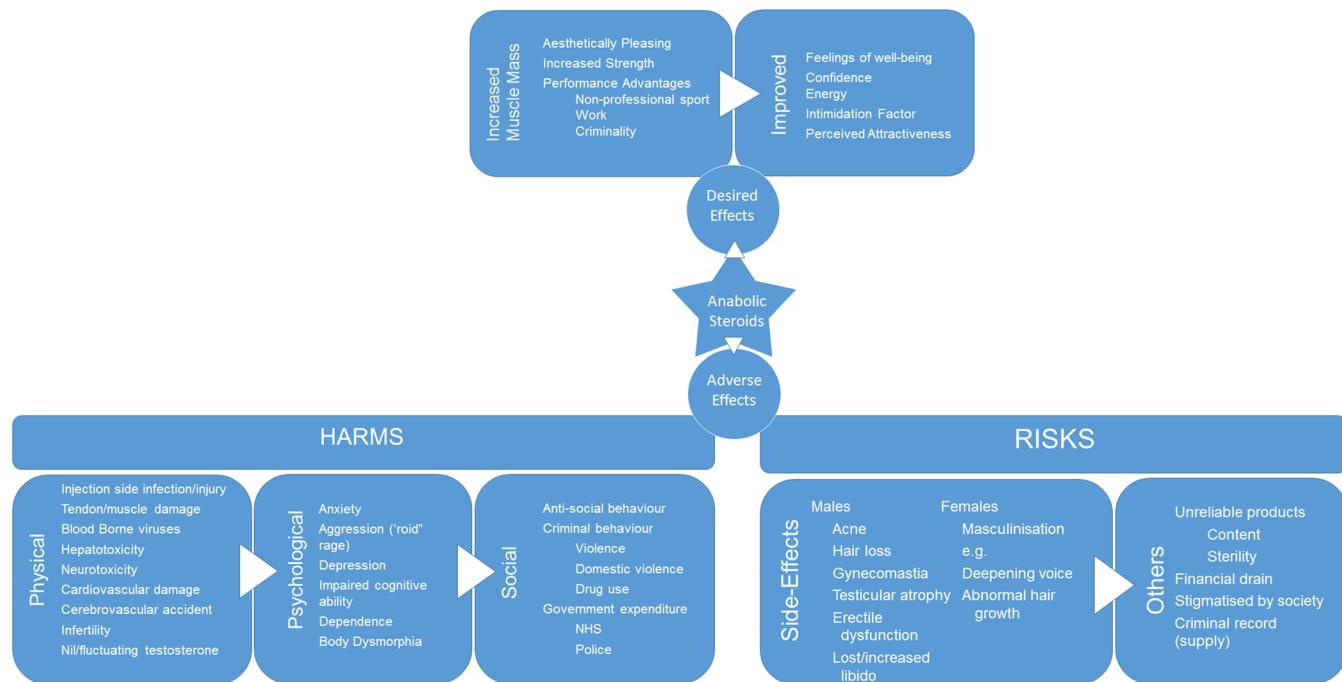
The increasingly lean and muscular body type now displayed by the mass media rarely exists in nature and could not be attained following the current recommendations on diet and exercise believed to constitute a "healthy lifestyle." In the hectic modern way of life, image and performance enhancing drugs (IPEDs) are becoming widely accepted as a convenient and readily obtainable means of attaining this widely advertised perfect body shape. Anabolic androgenic steroids (AASs) have become the performance enhancing drugs of choice (Bates & McVeigh, 2016). With the popularity of anabolic androgenic steroids for enhancing purposes soaring in recent years, the degree of anabolic androgenic steroid use appears to have reached a level which poses a serious risk of harm (Figure 1).

## 2 | ANABOLIC ANDROGENIC STEROIDS

Testosterone and dihydrotestosterone are endogenous male gonadal steroids (sex hormones). When present in excess, testosterone can

increase muscle growth and strength (Bhasin et al., 1996). The term anabolic androgenic steroids can include endogenously produced androgens but, for the purpose of this review, is intended to describe the wide range of synthetically manufactured abused derivatives of testosterone (Table 1). There is a large and increasing number of anabolic androgenic steroids available (Lood, Eklund, Garle, & Ahlner, 2012), few are legitimate, licensed medicinal products (only nine types of anabolic androgenic steroids were prescribed in England and Wales in 2018–2019, NHS England, 2019). The majority are "designer steroids" developed in research or underground laboratories to optimise muscle growth, while minimising unwanted androgenic effects.

The use of anabolic androgenic steroids outside of medicine was first exploited by professional athletes, most notably by competitive bodybuilders. With the impressive results of use clearly publicised in the media (Prendergast, Bannen, Erickson, & Honore, 2003), dramatic effects are well recognised by the public and use for amateur/cosmetic purposes has largely been driven by availability. In the United Kingdom, anabolic androgenic steroids are most commonly derived from testosterone in various forms, predominantly testosterone enanthate (Table 2; Bates & McVeigh, 2016; Hildebrandt,



**FIGURE 1** The effects of anabolic androgenic steroid use; the physical and psychological motivators for anabolic androgen steroid (AAS) use, contrasted with the numerous negative consequences of AAS use. The adverse effects range from minor side effects to serious physical and psychological harms

Alfano, & Langenbucher, 2010). This is reflective of male use. However, females are thought to prefer the milder effects of **stanazolol** (trade names, rexobol or winstrol), **oxandrolone** (anavar), or **nandrolone** (deca; Jespersen, 2012).

### 3 | ANABOLIC ANDROGENIC STEROIDS IN THE UNITED KINGDOM

Anabolic androgenic steroids are controlled in the United Kingdom as Class C substances under Part III of Schedule 2 of the Misuse of Drugs Act, 1971 and Schedule 4 of the Misuse of Drugs Regulations, 2001. It is not an offence to possess anabolic androgenic steroids for personal use or to import or export anabolic androgenic steroids if they are intended for personal use. Class C drugs represent the category of controlled drugs considered to present the least danger to the user/society and as such are not the highest priority for policing or the focus of campaigns to raise awareness about harm, safe use or use prevention (House of Commons Science and Technology Committee, 2006). However, such classifications do not recognise the relationship between harm and user numbers. Tens of thousands of individuals using a slightly harmful drug could be more detrimental to society than a few dozen individuals using a very dangerous substance. Consistent with this fairly relaxed legislative classification however, users do not feel stigmatised as "drug" users (Parker, Williams, & Aldridge, 2002; Radcliffe & Stevens, 2008). In fact, anabolic androgenic steroid users believe that by using anabolic androgenic steroids, they adopt a "lifestyle" incorporating well-being and exercise (Dunn, McKay, & Iversen,

2014; Hildebrandt, Harty, & Langenbucher, 2012; Ravn & Coffey, 2016). The majority maintain order in their lives, with nice homes and employment, some even holding professional positions (Dunn et al., 2014). This is in stark contrast to ad hoc recreational drug use, aligned with deterioration of social circumstances and self-destructive and antisocial behaviour. User detachment of anabolic androgenic steroid use from psychoactive "drug" abuse may be further encouraged by the substances being much more accessible (Brennan, Wells, & Van Hout, 2016). Readily available online (McDonald, Marlowe, Patapis, Festinger, & Forman, 2012) or purchased from friends or gym associates (Ip, Barnett, Tenerowicz, & Perry, 2011), there is no perception of duplicitous dealing, violence or organised crime.

The general public, however, do not share this perception. Perhaps driven by the injectable nature of anabolic androgenic steroids, the general public are likely to stigmatise anabolic androgenic steroid users, as they would "hard drug" users (Griffiths, Murray, & Mond, 2016). This may be validated by anabolic androgenic steroids being rated more harmful than the Class A substances **ecstasy**, **LSD**, **buprenorphine** and certain mushrooms (Nutt, King, & Phillips, 2010). Whilst this was almost entirely due to the harm posed to the user, the potential for social harm has been increasingly recognised through connections to binge drinking, use of psychoactive drugs (Darke, Torok, & Duflo, 2014; Hakansson, Mickelsson, Wallin, & Berglund, 2012; Ip et al., 2014; Leifman, Rehnman, Sjöblom, & Holgersson, 2011; Lood et al., 2012; Lundholm, Frisell, Lichtenstein, & Långström, 2015), spread of blood-borne viruses (BBVs; Hope et al., 2013), violence (Darke et al., 2014; Lundholm et al., 2015) and criminal, aggressive and antisocial behaviour (Hallgren et al., 2015).

**TABLE 1** Anabolic androgenic steroids available from online sources

Chemical name	Commercial name	Formulation	Pharmacology	Recommended effective dose (online community)		Popularity
				Male	Female	
Androisoxazol	Neo-Ponden	Oral	Cutting (fat loss)	15–40 mg·day <sup>-1</sup>	5–10 mg·day <sup>-1</sup>	
Bolasterone	Myagen	Oral	Bulking (muscle gain)	50–100 mg		
Bolazine caproate	Roxilon Inject	Injectable	Cutting	100–500 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	
Boldenone blend	Equilon 100	Injectable	All purpose	400–600 mg·week <sup>-1</sup>		
Boldenone undecylate	Equipoise®	Injectable	All purpose	200–600 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	<sup>a</sup>
Boldenone/methylboldenone blend	Drive®	Injectable	All purpose	300–600 mg·week <sup>-1</sup>		
Calusterone	Methosarb	Oral	Cutting	200 mg·day <sup>-1</sup>	200 mg·day <sup>-1</sup>	
Chlorodehydromethylandrostenediol	Halodrol	Oral	Bulking and strength	100–150 mg·day <sup>-1</sup>		
4-Chlorodehydromethyltestosterone	Oral Turinabol	Oral	Cutting	15–40 mg·day <sup>-1</sup>	2.5–5 mg·day <sup>-1</sup>	
Chloromethylandrostenediol	Promagnon	Oral	All purpose	50–100 mg		
Clostethol acetate	Megagrisevit-Mono®	Oral	Bulking	100–200 mg·day <sup>-1</sup>		
Danazol	Danocrine®	Oral	Androgenic	400 mg·day <sup>-1</sup>		
Demethylstanazolol tetrahydroxyanyl	Prostanazol	Oral	Cutting	100–150 mg·day <sup>-1</sup>	25 mg·day <sup>-1</sup>	
Desoxymethyltestosterone	Madol	Oral	Bulking and strength	40–60 mg·day <sup>-1</sup>		
Dihydroboldenone	1-Testosterone, DHB	Oral	Bulking	50–75 mg·day <sup>-1</sup>		
Dihydrotestosterone	Andractim®	Transdermal	Reduce gynecomastia	25 mg 2× per day		
Dihydrotestosterone	Neodrol	Injectable	All purpose	Generally advised against use		
Dimethazine	Roxilon	Oral	All purpose	10–20 mg·day <sup>-1</sup>	2.5 mg·day <sup>-1</sup>	
Dimethyltrienolone	Dimethyltrienolone	Oral	All purpose	20–40 mg·day <sup>-1</sup>		
Drostanolone enanthate	Masteron®	Injectable	Cutting	300–400 mg·week <sup>-1</sup>		<sup>a</sup>
Drostanolone propionate	Masteron®	Injectable	Cutting	100 mg/2 days	50–100 mg·week <sup>-1</sup>	<sup>a,b</sup>
Ethylestrenol	Orabolin®	Oral	Bulking	40 mg	10 mg	
Fluoxymesterone	Halotestin®	Oral	Cutting	10–40 mg·day <sup>-1</sup>		<sup>a</sup>
Formebolone, formyldienolone	Esiclene®	Injecting (oral available)	Bulking	As required (e.g., precompetition)	Irritant at injection site	
Furazabol	Miotolan®	Oral	Bulking/reduce cholesterol	50–100 mg·day <sup>-1</sup>		

(Continues)

TABLE 1 (Continued)

Chemical name	Commercial name	Formulation	Pharmacology	Recommended effective dose (online community)		Popularity
				Male	Female	
Hydroxytestosterone	Hydroxytest	Injectable	Bulking	300–2,000 mg·week <sup>-1</sup>	Not recommended	
Mepitiostane	Thioderon	Oral	Cutting	25–50 mg·day <sup>-1</sup>	20 mg·day <sup>-1</sup>	
Mestanolone	Ermalone	Oral	Cutting	10–20 mg·day <sup>-1</sup>	Not recommended	
Mesterolone	Proviron®	Oral	Cutting	25–200 mg·day <sup>-1</sup>		
Methandrostenolone, methandienone	Dianabol® Dbold	Oral	Bulking	15–50 mg·day <sup>-1</sup>	a	
Methenolone acetate	Primobolan®	Oral	Cutting	50–150 mg·day <sup>-1</sup>	25–75 mg·day <sup>-1</sup>	a
Methenolone enanthate	Primobolan® Depot	Injectable	Cutting	350–600 mg·week <sup>-1</sup>	100 mg·week <sup>-1</sup>	a
Methenitostane	Havoc	Oral	Cutting	10–20 mg·day <sup>-1</sup>	5 mg·day <sup>-1</sup>	
Methylandrostenediol	Methandriol	Oral or injectable	Bulking	30–50 mg·day <sup>-1</sup> (o) or 300–500 mg·week <sup>-1</sup> (i)		
Methyldebolone	Methyl-D	Oral	Bulking	2–10 mg·day <sup>-1</sup>	Not recommended	
Methylhydroboldenone	Methyl-1-testosterone	Oral	All purpose	10–50 mg·day <sup>-1</sup>	2.5 mg·day <sup>-1</sup>	
Methylhydrostanolone	Superdrol	Oral	Cutting	10–30 mg·day <sup>-1</sup>		
Methylhydroxyandrolone	MOHN	Oral	All purpose	10–30 mg·day <sup>-1</sup>	Not recommended	
Methylhydroxytestosterone acetate	MENT	Oral	Bulking	10 mg·day <sup>-1</sup>	Not recommended	
Methyltestosterone	Metandren	Oral	Bulking	25–100 mg·day <sup>-1</sup>		
Methyltrienolone	Metribolone	Oral	Cutting	500–750 mg·day <sup>-1</sup>		
Mibolerone	Cheque Drops®	Oral	Strength	200–500 mg·day <sup>-1</sup>		
Nandrolone blend	Dinandriol	Injectable	All purpose	200–600 mg·week <sup>-1</sup>	50 mg·week <sup>-1</sup>	
Nandrolone cyclohexylpropionate	Fherbolico	Injectable	Bulking	200–400 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	
Nandrolone cypionate	Dynabol®	Injectable	Bulking	200–400 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	
Nandrolone decanoate	Deca-Durabol®	Injectable	Bulking	200–600 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	a,b,c
Nandrolone hexyloxyphenylpropionate	Anadur®	Injectable	Bulking	200–600 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	
Nandrolone laurate	Laurabolin®	Injectable	All purpose	300–400 mg·week <sup>-1</sup>	50 mg·week <sup>-1</sup>	
Nandrolone phenylpropionate	Durabolin®, NPP	Injectable	Bulking	200–600 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	
Nandrolone undecanoate	Dynabol®	Injectable	All purpose	160–600 mg·week <sup>-1</sup>		
Nandrolone/methandriol blend	Libriol	Injectable	Bulking	200–600 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	
Nandrolone/methandriol blend	Tribolin	Injectable	Bulking (weak)	200–400 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	
Nandrolone/methandriol blend	Nandrabolin	Injectable	Bulking (weak)	200–400 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	
Norbolethone	Genabol	Oral	Bulking (weak)	10–15 mg·day <sup>-1</sup>	5 mg·day <sup>-1</sup>	
Norclostebol acetate	Anabol 4–19	Injectable	Bulking/cutting	200–600 mg·week <sup>-1</sup>	50–100 mg·week <sup>-1</sup>	

(Continues)

TABLE 1 (Continued)

Chemical name	Commercial name	Formulation	Pharmacology	Recommended effective dose (online community)		Popularity
				Male	Female	
Norethandrolone	Nilevar®	Oral	Bulking/cutting	20–40 mg·day <sup>-1</sup>	2.5–10 mg·day <sup>-1</sup>	
Normethandrolone	Orgasteron	Oral	Bulking	10–40 mg·day <sup>-1</sup>	300–800 mg·week <sup>-1</sup>	
Oxabolone cyionate	Steranabol Ritarido	Injectable	Bulking	50–80 mg·day <sup>-1</sup>	40–150 mg·week <sup>-1</sup>	
Oxandrolone	Anavar, Oxandrin, Lonavar	Oral	Cutting	20–40 mg·day <sup>-1</sup>	10–20 mg·day <sup>-1</sup>	a,c
Oxymesterone	Oranabol	Oral	Cutting	100 mg·day <sup>-1</sup>	10 mg·day <sup>-1</sup>	a
Oxymetholone	Anadrol®-50	Oral	Bulking	50–100 mg·day <sup>-1</sup>	5–10 mg·day <sup>-1</sup>	a,c
Quinbolone	Anabolicum Vister	Oral	All purpose	25–50 mg·day <sup>-1</sup>	20 mg/4 days	
Stanozolol	Winstrol®	Oral	Cutting	50 mg·day <sup>-1</sup>	350–700 mg·week <sup>-1</sup>	
Stanozolol	Winstrol® Depot	Injectable	Cutting	5–10 g·day <sup>-1</sup>	30 mg/2 per day	
Stenbolone acetate	Anatrofin	Injectable	Cutting	2.5–5 mg·day <sup>-1</sup>	300–2,000 mg·week <sup>-1</sup>	
Testosterone	Androderm®	Transdermal	All purpose	5–10 g·day <sup>-1</sup>	Not recommended	
Testosterone	AndroGel®	Transdermal	All purpose	30 mg/2 per day	150–450 mg/3–6 months	
Testosterone	Striant®	Sublingual	All purpose	300–2,000 mg·week <sup>-1</sup>	400–600 mg·week <sup>-1</sup>	
Testosterone	Testoderm®	Transdermal	All purpose	300–2,000 mg·week <sup>-1</sup>	200–600 mg·week <sup>-1</sup>	
Testosterone	Testopel®	Subcutaneous implant	All purpose	300–2,000 mg·week <sup>-1</sup>	250–1,000 mg·week <sup>-1</sup>	
Testosterone blend	Deposterona	Injectable	All purpose	Not recommended	Not recommended	
Testosterone blend	Equitest 200	Injectable	All purpose	Not recommended	Not recommended	
Testosterone blend	Omnadren® 250	Injectable	All purpose	Not recommended	Not recommended	
	Primobolan	Sustanon® 100 Propionate, Phenylpropionate, Isocaproate, Decanoate	All purpose	500–2,000 mg·week <sup>-1</sup>	500–2,000 mg·week <sup>-1</sup>	
Testosterone blend	Sustanon® 250	Injectable	All purpose	500–2,000 mg·week <sup>-1</sup>	Not recommended	a,b
Testosterone blend	Triolandren	Injectable	All purpose	200–400 mg·week <sup>-1</sup>	25 mg·week <sup>-1</sup>	
Testosterone bucilate	20 AET-1	Injectable	All purpose	1,000 mg·month <sup>-1</sup>	Not recommended	
Testosterone cyclohexylpropionate	Andromar Retard	Injectable	All purpose	300–600 mg·week <sup>-1</sup>		

(Continues)

**TABLE 1** (Continued)

Chemical name	Commercial name	Formulation	Pharmacology	Recommended effective dose (online community)		Popularity
				Male	Female	
Testosterone cypionate and propionate	Sten	Injectable	All purpose	200–2,000 mg·week <sup>-1</sup>	Not recommended	
Testosterone cypionate	Depo®-Testosterone Neotest 250	Injectable	All purpose	300–2,000 mg·week <sup>-1</sup>	Not recommended	a,b
Testosterone decanoate		Injectable	All purpose	300–2,000 mg·week <sup>-1</sup>	Not recommended	
Testosterone enanthate	Delatestryl® or Primosteston	Injectable	All purpose	300–2,000 mg·week <sup>-1</sup>	Not recommended	a,b,c, Extremely popular online and most common in the United Kingdom
Testosterone hexahydrobenzoate	Sterandryl Retard	Injectable	All purpose	300–2,000 mg·week <sup>-1</sup>	Not recommended	
Testosterone isobutyrate	Agovirin Depot	Injectable	All purpose	300–2,000 mg·week <sup>-1</sup>	Not recommended	
Testosterone nicotinate	Bolfortan	Injectable	All purpose	300–2,000 mg·week <sup>-1</sup>	Not recommended	
Testosterone phenylacetate	Perandren	Injectable	All purpose	300–2,000 mg·week <sup>-1</sup>	Not recommended	
Testosterone phenylpropionate	Testolent	Injectable	All purpose	35–1,000 mg·week <sup>-1</sup>		
Testosterone propionate and estradiol	Synovex®	Injectable	All purpose	300–2,000 mg·week <sup>-1</sup>	Not recommended	
Testosterone propionate	Oreton	Injectable	All purpose	200–400 mg·week <sup>-1</sup>	25 mg·week <sup>-1</sup>	a,b
Testosterone propionate/enanthate blend	Testoviron® blend	Injectable	All purpose	100–1,000 mg·week <sup>-1</sup>		a
Testosterone suspension	Andronaq	Injectable	All purpose	50–200 mg·day <sup>-1</sup>	Not recommended	
Testosterone undecanoate	Andriol®	Oral	All purpose	120–500 mg·day <sup>-1</sup>		
Testosterone undecanoate	Nebido	Injectable	All purpose	1,000 mg·month <sup>-1</sup>	Not recommended	
Testosterone/oestrogen blend	Estandron	Injectable	All purpose	1,000–1,500 mg·week <sup>-1</sup>		
Testosterone/nandrolone/methandriol blend	Spectrol	Injectable	All purpose	200–2,000 mg·week <sup>-1</sup>	Not recommended	
Tetrahydrogestrinone	THG	Oral	Bulking	2–5 mg·day <sup>-1</sup>	Not recommended	
Thiomesterone	Emdabol	Oral	Bulking	15–25 mg·day <sup>-1</sup>	Not recommended	
Trenbolone acetate	Finajet, Fina	Injectable	All purpose	50–100 mg/2 days	Not recommended	a,b
Trenbolone enanthate	Trenabol	Injectable	All purpose	150–450 mg·week <sup>-1</sup>		b
Trenbolone hexahydrobenzylcarbonate	Parabolan®	Injectable	All purpose	300–500 mg·week <sup>-1</sup>	Not recommended	

Note. Presented are some of the many AAS substances which are available to buy online. The information presented comes from online user reports and supplier marketing information. Those which are believed to be most popular amongst certain user groups have been highlighted.

<sup>a</sup>Popular amongst those purchasing online (Dynamic Sports Nutrition, 2016).

<sup>b</sup>Popular amongst U.K. users (Bates & McVeigh, 2016).

<sup>c</sup>Popular amongst female users (Jespersen, 2012).

**TABLE 2** Anabolic androgenic steroids (AASs) in use in the United Kingdom (Bates & McVeigh, 2016)

Anabolic androgenic steroid	Percentage of performance enhancing drug (IPED) users using in past year
Testosterone enanthate	60
Sustanon	43
Testosterone propionate	38
Nandrolone decanoate	36
Underground lab blend	34
Trenbolone acetate	33
Testosterone cypionate	30
Drostanolone propionate	27
Trenbolone enanthate	25
Boldenone (Equipoise)	25
Stanozolol (oral AAS)	11
Testosterone suspension	9

#### 4 | ANABOLIC ANDROGENIC STEROID USER DEMOGRAPHICS

Anabolic androgenic steroid users are typically in their late 20s to early 30s and most often are heterosexual males (Hope et al., 2016; Ip et al., 2011; Ip et al., 2012), although gay/bisexual men are overrepresented in the anabolic androgenic steroid community (42%; Van Beek & Chronister, 2015). Most users are single and participate in recreational exercise (Ip et al., 2012), largely composing of weight training (Brennan et al., 2016). Gym users, especially private gym users, are more likely to be offered anabolic androgenic steroids (Leifman et al., 2011), which may partially contribute to popularity amongst this demographic. In the United Kingdom, anabolic androgenic steroid

users display lower levels of education compared to non-users (Kanayama, Kean, Hudson, & Pope, 2013).

Females also use anabolic androgenic steroids, but to a much lesser extent (Börjesson, Gårevik, Dahl, Rane, & Ekström, 2016), around 8% to 16% of anabolic androgenic steroid users in the United Kingdom and Ireland are thought to be female (Chandler & Mcveigh, 2013; Mcveigh, Bates, & Chandler, 2015). Information related to female users is, therefore, limited. Most women are introduced to anabolic androgenic steroids by a male figure (Börjesson et al., 2016). Yet the male-dominated online community exhibit hostility towards female users, warning against masculinisation and infertility (Jespersen, 2012). The online user community are also unwelcoming of adolescent males. Adult male users discourage younger men from anabolic androgenic steroid use until at least 21 years of age, when natural testosterone has peaked (Chandler & Mcveigh, 2013).

The majority of U.K. users are aged over 18 at the time of first use (Chandler & Mcveigh, 2013), but use amongst adolescents has been recognised (Brennan et al., 2016; Eisenberg, Wall, & Neumark-Sztainer, 2012; Ip et al., 2012). The last available figures for England and Wales indicated use in males as young as 11 (Fuller & Hawkins, 2013) and in Scotland, anabolic androgenic steroid use was recorded at 1% for 13-year-old boys and 1% of 15-year-old boys (over 2,200 respondents; NHS Scotland, 2014). This is low compared to findings elsewhere, where up to 5.9% of teenage school boys were reported to have tried anabolic androgenic steroids (Eisenberg et al., 2012; Heimly Jenssen & Johannessen, 2015).

#### 5 | POPULARITY OF ANABOLIC ANDROGENIC STEROIDS

Reliable data concerning anabolic androgenic steroid use are very difficult to obtain. The last estimate in England and Wales was that

**TABLE 3** Estimated anabolic androgenic steroid (AAS) use in the United Kingdom (Home Office, 2018)

Year	Recent drug use		Drug use in last year		
	16- to 59-year-olds		16- to 59-year-olds		16- to 24-year-olds
	Users	(up to)	Users	(up to)	
2017/2018	361,000	0.2	84,000	0.3	
2016/2017	411,000	0.2	83,000	0.4	
2015/2016	320,000	0.2	75,000	0.1	
2014/2015	340,000	0.2	98,000	0.5	
2013/2014	317,000	0.2	91,000	0.5	
2012/2013	311,000	0.2	79,000	0.2	
2011/2012	262,000	0.2	89,000	0.3	
2010/2011	243,000	0.2	68,000	0.3	
2009/2010	259,000	0.1	65,000	0.4	
2008/2009	212,000	0.1	61,000	0.3	
2007/2008	215,000	0.1	28,000	0.1	

411,000 adults had used an anabolic androgenic steroid (Home Office, 2018). This represented substantial growth, an approximate doubling over a 10-year period (Table 3). There are no national surveys which indicate anabolic androgenic steroid use in Scotland, but Needle and Syringe Programme (NSP) data also indicate substantial escalation. The number of attendees and needles dispensed reached an all-time high in 2014/2015, showing a 45% and 15% rise on the previous year, respectively (NHS Scotland Information Services Division, 2016). With no associated increase in supply of psychoactive drug paraphernalia, anabolic androgenic steroids were believed responsible for the upsurge. Provision of equipment for injection of performance enhancing drugs continued to grow in subsequent years (NHS Scotland, 2018). Around two thirds of NSP new clients are anabolic androgenic steroid users (Whitfield, Reed, Chandler, Bates, & McVeigh, 2012) and up to 86% of clients overall (Kimergård & McVeigh, 2014). NSP data are expected to underestimate anabolic androgenic steroid use as needles can be obtained from other sources, and some users may embark on needle and/or syringe reuse and sharing (Bates & McVeigh, 2016).

There is a high incidence of injection site infection and injury reported by anabolic androgenic steroid users (Hope et al., 2014), but many never seek specialist help with correct injection techniques, relying instead on the guidance of other users or information from their supplier (Hanley Santos & Coomber, 2017). The injection of anabolic androgenic steroid differs from psychoactive drugs, which are typically injected intravenously. Anabolic androgenic steroids are usually injected into a large muscle (buttocks or thigh) and require a longer, wider gauge needle than used for intravenous injections, a fact unknown to some users and a method ignored by others as they find it technically difficult (Hope et al., 2014). Also, some users are known to perform "spot injections." This is where anabolic androgenic steroids are injected into targeted, smaller muscle groups (e.g., biceps; Bates & McVeigh, 2016; Hope et al., 2014; Kimergård & McVeigh, 2014) in the belief that the anabolic action will be localised (Evans, 1997). However, this practice requires very good injection technique to avoid complications, such as blood vessel breakage, muscle or nerve damage, or even paralysis (Evans, 1997). Spot injections are concomitant with injection site infections, abscesses and tumours (Hope et al., 2014; Weinreb, Goldblum, & Rubin, 2010), as are the reuse of needles and/or syringes and the use of multiple injection vials (Graham et al., 2009; Hope et al., 2014; Pai, Parampalli, Hettiarachchi, & Ahmed, 2013). Unlike most psychoactive drugs, anabolic androgenic steroids are usually purchased as a liquid, ready for injection. This represents a greater risk for bacterial contamination (Hope et al., 2014), especially as many anabolic androgenic steroids are produced without the necessary regard to quality and safety. Anabolic androgenic steroids purchased online have been found to be contaminated with microorganisms which could result in abscess formation (Graham et al., 2009), serious infection and in extreme cases could result in death (Perera, Steinbeck, & Shackel, 2013; Russo et al., 2012).

Anabolic androgenic steroids are usually sold by websites which claim to specialise in either medicines or dietary supplements (Cordaro, Lombardo, & Cosentino, 2011). These are not

pharmaceutical and the content of anabolic androgenic steroids purchased online cannot be guaranteed. Products have widely been identified as counterfeit, misleadingly named, and labelled with incorrect contents and dosages (Abbate et al., 2014; Coomber, Pavlidis, Wilde, Schmidt, & Redshaw, 2014; Cordaro et al., 2011; da Justa Neves, Marchetti, & Caldas, 2013; de Moura Ribeiro, Boralle, Philippe, Pezza, & Pezza, 2018; Graham et al., 2009; Weber, Kamber, Lentillon-Kaestner, Krug, & Thevis, 2015). Thus, despite carefully planned administration regimes, users cannot be sure that what they purchase really contains the substance they need, at the correct dose. The unreliable nature of purchasing anabolic androgenic steroid products is well recognised within the user community, many of whom contribute to websites that rate online suppliers and their products. This can help users avoid suppliers who fail to deliver or supply poor products. The health risks of such uncertainty do not appear to trouble users who are more concerned about being swindled or the product not being efficacious (Kimergård & McVeigh, 2014). Generally, the only way to know what a purchased vial contains is to use it and experience the strength and/or bodily effects. Often, the bodily gains do not manifest, or there are unexpected side effects, but this does not discourage use of anabolic androgenic steroids (Jespersen, 2012).

## 6 | HARMS OF ANABOLIC ANDROGENIC STEROID USE

In 2010, the UK Advisory Council on the Misuse of Drugs (2010) highlighted important gaps in available knowledge surrounding increasing anabolic androgenic steroid use. The many obstacles to investigating the dangers of anabolic androgenic steroid use were well summarised, and these restraints have not eased with time. The study of anabolic androgenic steroids in adult males remains limited due to experimental and ethical restrictions. The information that is available generally comes from surveys or experiments in which anabolic androgenic steroid use is self-reported or from hospital/post-mortem case studies. Thus, the degree of anabolic androgenic steroid ingestion is never reliably known (even by those consuming them) and no account can be recorded of possible considerable polypharmacy, employed by most anabolic androgenic steroid users (Lusetti, Licata, Silingardi, Reggiani Bonetti, & Palmiere, 2015; Montisci et al., 2011; Shamloul, Aborayah, Hashad, & Abd-Allah, 2014).

As dominant users, most investigations of anabolic androgenic steroid toxicity focus on adult males. Little is known of the harmful effects of anabolic androgenic steroid use in females or adolescents, the groups in which they are expected to be most hazardous. Lacking in natural testosterone, females appear to be more susceptible to toxic effects (Börjesson et al., 2016) and represent a high proportion (82.5%) of hospitalisations (Henrique, Da, & Junior, 2013). This could however be related to the apparent preference amongst female users for oral anabolic androgenic steroids (Heimly Jenssen & Johannessen, 2015), which have greater toxicity. Commonly recognised (irreversible) effects in females are those associated with masculinisation, for example deepening of the voice and abnormal hair growth (Jespersen,

2012). Adverse effects typically experienced in males include acne, hair loss, painful gynecomastia and testicular atrophy. Side effects which cannot be easily recognised by the user, however, include oligo-azospermia, damage to tendons and muscles, and more seriously, damage to the cardiovascular system and internal organs. Adverse effects of anabolic androgenic steroid use are largely dose dependent and reversible upon cessation of use, although there is some evidence to suggest that carcinogenesis may arise from even short-term use (Frankenfeld et al., 2014; Martins, Gomes, Aguiar O Jr, Medalha, & Ribeiro, 2010).

During anabolic androgenic steroid use, natural testosterone secretion can be much reduced or even absent (Kanayama et al., 2015). This can continue into the off-cycle and periods of testosterone deprivation may result. Immediate effects of testosterone deficiency in adults include loss of libido, impaired erectile function and depression (El Osta et al., 2016; Nieschlag & Vorona, 2015). Symptoms can persist long after use has been discontinued and in some cases, may not dissipate, even following medical intervention. This suggests permanent damage occurring to the testosterone producing Leydig cells (Kanayama et al., 2015). This may explain why anabolic androgenic steroid use and resultant lack of natural testosterone production in adolescence can lead to testicular atrophy and disrupted reproductive behaviours in adulthood (Olivares et al., 2014).

Damage to the cardiovascular system may also remain masked and may not manifest to a significant degree until later in life (Reza, Ågren, & Thiblin, 2012), although there is mounting evidence to link anabolic androgenic steroid-associated cardiovascular damage and thrombosis with cerebrovascular accident in younger anabolic androgenic steroid users (Cooper, Reeve, & Doherty, 2011; Shimada et al., 2012; Youssef, Alqallaf, & Abdella, 2011). Accounts of alterations and effects on the cardiovascular system are somewhat inconsistent. Repeatedly reported during long-term and/or high-dose anabolic androgenic steroid use are negative effects on lipid profiles, increased BP, myocardial deformity and dysfunction (particularly of the left ventricle), and sudden death (Achar, Rostamian, & Narayan, 2010; Alizade et al., 2015; Angell et al., 2012; Baggish et al., 2010; Baggish et al., 2017; Kaufman et al., 2015; Maior et al., 2010; Reza et al., 2012; Rothman et al., 2011). The deformity to the myocardium and coronary arteries has been observed to be so significant that it may constitute a serious public health concern (Baggish et al., 2017).

Damage to the cardiovascular system could, however, be compounded by additional substances allied with anabolic androgenic steroid use, in particular, stimulants such as cocaine and "fatburners," which are well documented to adversely affect the heart. Multi-drug use by of anabolic androgenic steroid users could also be contributing to the implication of anabolic androgenic steroids in causing severe liver disease (Elsharkawy et al., 2012; Robles-Diaz et al., 2015; Simões Tanasov et al., 2014). 17 $\alpha$  alkyl-ation of steroids (e.g. methyltestosterone, methandrostenolone, oxymetholone, oxandrolone and stanozolol) to increase their oral bioavailability slows their metabolism in the liver, meaning that hepatocytes and cholangiocytes are exposed to the drug for longer

periods, resulting in increased toxicity (Elsharkawy et al., 2012). Injectable anabolic androgenic steroids may still cause alterations in liver structure and function when consumed at high doses and for longer periods (Chandler & McVeigh, 2013). Such use can also contribute to kidney damage (Robles-Diaz et al., 2015) and potential to develop Wilm's tumour (El Osta et al., 2016). The raised body mass index and high-protein diets of many anabolic androgenic steroid users increase susceptibility to nephrotoxicity (Harrington, Ali, & Chan, 2011). At least one case is reported in the literature where kidney damage was so severe that transplantation was required (Harrington et al., 2011).

## 6.1 | Blood-borne viruses

In addition to the direct actions of anabolic androgenic steroid substances, their use in the form of injectables carries further potential for harm. Injected intramuscularly, rather than intravenously, users generally do not perceive themselves to be at high risk of contracting blood-borne viruses (Van Beek & Chronister, 2015). This could explain the much lower levels of hepatitis B vaccinations or hepatitis C testing seen in anabolic androgenic steroid users compared to other injecting drug users (Anon, 2015). Although the rate of hepatitis B and C infection amongst anabolic androgenic steroid users is lower than in those injecting psychoactive substances, it is higher than the occurrence of these blood-borne viruses in the general U.K. population. Anabolic androgenic steroid users also exhibit increased rates of HIV infection, which are equal to that of intravenous drug users (Anon, 2015; Hope et al., 2016).

To reinforce the message that needles should never be reused or shared and improve access to clean equipment, it was recommended that NSPs offer evening clinics specifically for anabolic androgenic steroid users (The Scottish Government, 2010). Anabolic androgenic steroid users had expressed unwillingness to attend NSPs, as they did not wish to be associated with "problem" drug users, and many were unable to attend as they were in full-time employment. Additionally, it was made possible for attendees to collect unlimited numbers of needles and syringes to allow for fewer visits. Two thirds of anabolic androgenic steroid users now obtain injection equipment from an NPS (Bates & McVeigh, 2016); this is a change from 2013 when most users purchased equipment online (Chandler & McVeigh, 2013). The more challenging issue now is that attendees collect equipment for onward distribution (Van Beek & Chronister, 2015). Around one fifth of users report collecting equipment to give to others (Bates & McVeigh, 2016), and those in receipt will not benefit from the important advice on safe use, injection, and disposal of needles. Neither will they receive sexual health advice, which appears to be a priority as precarious sexual conduct may be a more significant contributor to the spread of blood-borne viruses in this group. Only a small amount of needle sharing (1%, Bates & McVeigh, 2016, to 6%, Hope et al., 2016) and multiple-dose vial sharing (7%, Whitfield et al., 2012, to 12%, Bates & McVeigh, 2016) takes place.

## 7 | MOTIVATORS FOR ANABOLIC ANDROGENIC STEROID USE

Almost unanimously, the reason given for anabolic androgenic steroid use is to increase muscle mass (Bates & McVeigh, 2016; Hanley Santos & Coomber, 2017), commonly to improve physical appearance (Hanley Santos & Coomber, 2017; Ip et al., 2014; Murray, Griffiths, Mond, Kean, & Blashill, 2016). The greatest motivator for this group is the rapid and convenient results of anabolic androgenic steroid use on muscle mass, which, even without accompanying exercise, are greater than those that can be achieved by exercise alone (Bhasin et al., 1996). Use is encouraged through contact with other users (Hildebrandt et al., 2012) who can vouch for the outcome. A large proportion of those wishing to improve their appearance are inspired to use anabolic androgenic steroids in pursuit of health and well-being. Many start out with use of health supplements, and there are strong associations between supplement use and use of anabolic androgenic steroids (Heimly Jenssen & Johannessen, 2015; Hildebrandt et al., 2012; Leifman et al., 2011).

Dietary supplements are often marketed as safer and legal alternatives to anabolic androgenic steroids. However, the reliability of certain "specialist" supplements cannot be assured. Bulk products are imported to the United Kingdom, often from China (Advisory Council on the Misuse of Drugs, 2010), and processed and packaged for sale in shops or online (Abbate et al., 2014). It is not unusual for these products to contain controlled anabolic androgenic steroids (Abbate et al., 2014; Chahla, Hammami, & Befeler, 2014; Cordaro et al., 2011; El Sherrif et al., 2013) and around half of the dietary supplements available online contain undeclared anabolic androgenic steroids (Cordaro et al., 2011). Even where anabolic androgenic steroids are listed in the ingredients, they may not be immediately recognisable as an anabolic androgenic steroid. Plus, ingredient lists cannot be trusted. Often, an anabolic androgenic steroid may be listed as an ingredient of a supplement, but it will not contain the anabolic androgenic steroid as advertised on the label. Rather, it will be found to contain a different anabolic androgenic steroid, usually present at a concentration in excess of that required to have an effect (Abbate et al., 2014). This could have serious implications, particularly in naïve users unaware that they are consuming what is considered to be a large dose. These individuals may be teenage boys, who have not yet reached sexual maturity and are therefore more susceptible to irreversible harm through anabolic androgenic steroid use (Clark et al., 2006; Clark & Henderson, 2003; Henderson, Penatti, Jones, Yang, & Clark, 2006; Ramos-Pratts, Rosa-González, Pérez-Acevedo, Cintrón-López, & Barreto-Estrada, 2013). Adolescent males have frequently reported behaviours such as those associated with the use of protein powders/shakes and other supplements to increase muscle size and tone (Eisenberg et al., 2012). In fact, a perception of being over or under weight as an adolescent has been linked to initiating anabolic androgenic steroid use (Heimly Jenssen & Johannessen, 2015; Pope, Kanayama, & Hudson, 2012).

Concerns over body image and body dissatisfaction are common factors amongst those who use anabolic androgenic steroids (Björk,

Skårberg, & Engström, 2013; Jampel, Murray, Griffiths, & Blashill, 2016). Muscle dysmorphia is a psychiatric condition (classified under the conditions DSM-5 300.7 ICD-10 F22.8b, American Psychiatric Association, 2013), where the sufferer is obsessively and compulsively driven towards achieving a lean and muscular body. Also known as "reverse anorexia nervosa," it is a fear of being too small (Björk et al., 2013). It usually manifests in careful eating with excessive weightlifting, and sufferers often use anabolic androgenic steroids. In those suffering muscle dysmorphia, body satisfaction is unlikely to improve with anabolic androgenic steroid use (Heimly Jenssen & Johannessen, 2015) and anabolic androgenic steroids have actually been implicated in the development and maintenance of the disorder (Björk et al., 2013).

A particularly muscular physique may be pursued for reasons other than to improve body image, for example, advantages in non-professional sports (especially weightlifting and powerlifting) or to increase strength, achievements or even intimidation in certain professions such as security for bars and clubs. Moreover, a minority of users have been reported as using anabolic androgenic steroid in order to appear threatening and/or increase strength to aid in the commission of crime (Lood et al., 2012). One such group of anabolic androgenic steroid users, familiar with violence, are heroin users. Increased size and strength from anabolic androgenic steroids prevent a heroin user from being physically intimidated in interactions with others involved in the illicit drug trade (Cornford, Kean, & Nash, 2014). Anabolic androgenic steroids can also provide a means to conceal current or past problem drug use by obscuring the excessive weight loss that is a recognisable indicator (Cornford et al., 2014; Hanley Santos & Coomber, 2017; Nøkleby & Skárderud, 2013). As heroin users are often stigmatised by society, a healthy body becomes an indicator of a "good" person which can be used to support access to housing or employment (Nøkleby & Skárderud, 2013). Anabolic androgenic steroids provide an easy means of appearing healthy and trustworthy (Cornford et al., 2014).

### 7.1 | Dependency

Upon commencing anabolic androgenic steroid use, it is possible that dependency becomes a motivator for continued use. Around one quarter (Ip et al., 2012) to one third (Hildebrandt, Langenbucher, Lai, Loeb, & Hollander, 2011) of anabolic androgenic steroid users claim to be dependent. "Androgen dependence syndrome" describes continued anabolic androgenic steroid use despite prominent adverse medical, psychological or social effects (Kanayama, Brower, Wood, Hudson, & Pope HG Jr, 2009). However, although anabolic androgenic steroid users may experience adverse effects during anabolic androgenic steroid use, these tend to increase during periods of abstinence. The severity of these negative side effects experienced during off-cycles may create difficulty for users to permanently stop, as they are eager to use again to ease their physical or emotional suffering (Kanayama et al., 2015). Additionally, continued use is sustained by the positive effects experienced by many users which include not only

the desired increase in muscle mass but also feelings of well-being (Advisory Council on the Misuse of Drugs, 2010), which have been likened to psychoactive drug use (Hanley Santos & Coomber, 2017). Similar to psychoactive drug users, anabolic androgenic steroid users describe how anabolic androgenic steroids use can produce a mental "high," by making them feel more energetic and confident, from the belief that they have extreme strength (Cornford et al., 2014; Hanley Santos & Coomber, 2017; Nøkleby & Skårderud, 2013).

Thus, anabolic androgenic steroid dependency is not thought to be a physiological condition. Rather, it is a psychological addiction. The user is compelled to continue to use the drug but to stop would not result in a withdrawal syndrome (National Institute on Drug Abuse, 2007). It is actually possible that anabolic androgenic steroid use creates a vulnerability in the user to develop a dependence syndrome. Animal studies have highlighted the importance of sex hormones as modulators of drug sensitivity (Marusich, Craft, Lefever, & Wiley, 2015; Struik, Sanna, & Fattore, 2018). Chronic anabolic androgenic steroid use is understood to suppress the endocannabinoid system (Struik et al., 2017), with consequent reduction in reward function (Seitz et al., 2017; Wallin, Alves, & Wood, 2015). This manifests as a reduction in neurochemical and behavioural effects of a range of drugs of abuse (cannabinoids, Mhillaj et al., 2015; Struik et al., 2017; cocaine, Kailanto, Kankaanpää, & Seppälä, 2011; Kurling-Kailanto, Kankaanpää, & Seppälä, 2010; Mhillaj et al., 2015; and amphetamines and alcohol, Mhillaj et al., 2015). In animals, this was offset by increased drug (cannabis) administration (Struik et al., 2017). Thus, anabolic androgenic steroid users are considered to be at greater risk of initiating use, struggling with maintenance of use and development of addiction (Struik et al., 2017; Struik et al., 2018). Behaviours which continued beyond anabolic androgenic steroid elimination, suggesting changes to the CNS caused by anabolic androgenic steroids, may be long lasting (Kailanto et al., 2011; Kurling-Kailanto et al., 2010; Struik et al., 2017). Increased vulnerability to drug use in animals was reflected in surveys of human anabolic androgenic steroid users.

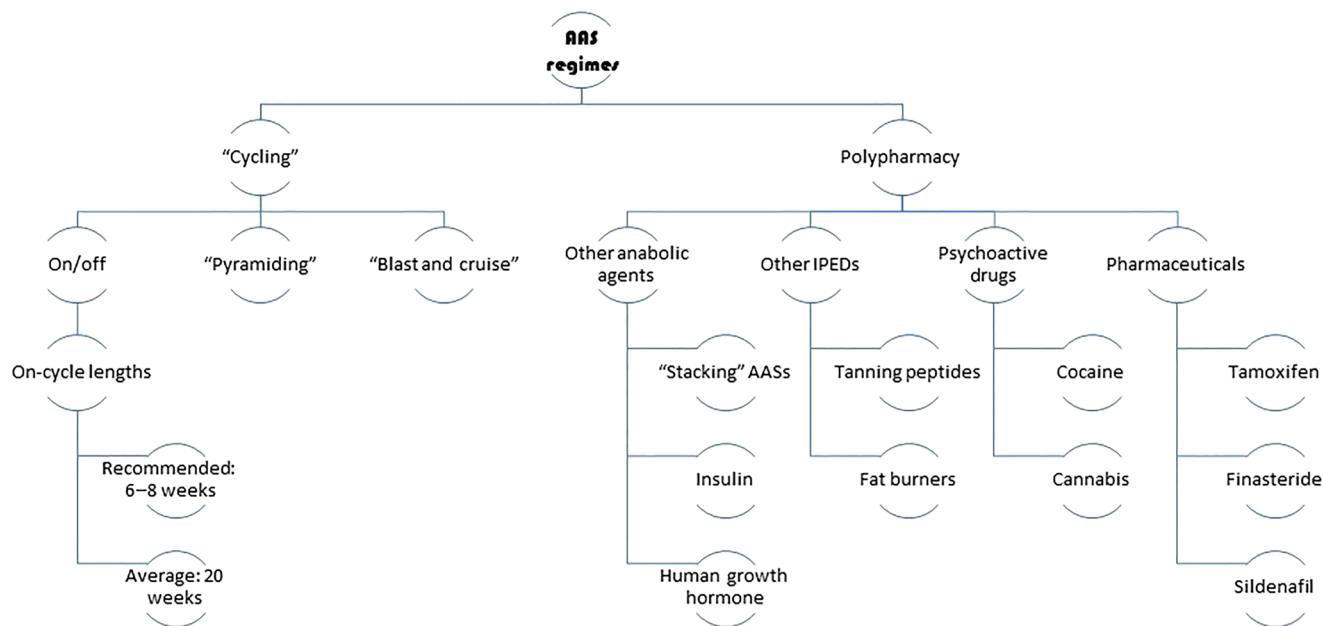
Frequency of substance misuse was demonstrated to be related to use anabolic androgenic steroids (Lundholm et al., 2015; Sagoe, Torsheim, Molde, Andreassen, & Pallesen, 2015). Substantial psychoactive drug use has been observed amongst anabolic androgenic steroid users (Hallgren et al., 2015; Hope et al., 2013; Lood et al., 2012; Lundholm et al., 2015; Molero, Bakshi, & Gripenberg, 2017). Almost 80% of U.K. anabolic androgenic steroid users have used an illegal drug (Chandler & Mcveigh, 2013; Lorang, Callahan, Cummins, Achar, & Brown, 2011) and around one third (32%) reported recent (1 year) use (Bates & McVeigh, 2016; Chandler & Mcveigh, 2013; Mcveigh et al., 2015), most commonly cannabis (24%) and cocaine (22%; Bates & McVeigh, 2016). In fact, cocaine is substantially more prevalent amongst anabolic androgenic steroid users than the general public (Hope et al., 2013; Kanayama, Brower, Wood, Hudson, & Pope Jr, 2010); 46% of U.K. anabolic androgenic steroid users declared recent use (Hope et al., 2013; Ip et al., 2011) compared to 2.3% of the U.K. general public (Home Office, 2015).

As sex also stimulates reward centres in the brain, anabolic androgenic steroid-induced dysfunction of reward circuits is postulated to influence sexual behaviour. Anabolic androgenic steroids have been reported to increase sexual arousal and desire in human subjects and exhibit dose-dependent stimulation of sexual behaviour in animals (Kim & Wood, 2014). Rat models have shown, however, that there is no associated increase in willingness to work for sexual reward (Kim & Wood, 2014). Rather, when sexual opportunities are presented, they are more likely to be accepted. This, combined with anabolic androgenic steroids-induced increase in impulsivity and reduction in awareness of possible negative consequences (Hildebrandt, Langenbucher, Flores, Harty, & Berlin, 2014), results in increased risky sexual behaviours (not using condoms and sex with multiple partners; Begley et al., 2017; Hope et al., 2013). This is particularly true of homosexual anabolic androgenic steroid users who also reported unprotected sex with men of unknown HIV status (Bolding, Sherr, Maguire, & Elford, 1999). Unsurprisingly, therefore, high testosterone levels have been linked with increased likelihood of contracting sexually transmitted disease (Booth, Johnson, & Granger, 1999).

## 8 | HOW ANABOLIC ANDROGENIC STEROIDS ARE USED

Anabolic androgenic steroid user education and administration regimes tend to develop through imparted knowledge and experiences of other users (Chandler & Mcveigh, 2013) via online discussion forums, user-produced websites and in gyms. Users share a strong sense of community which fosters an intense support network to encourage each other towards body image or performance goals (Hanley Santos & Coomber, 2017). Members of the community can quickly learn and "optimise" complex nutritional, exercise, and anabolic androgenic steroids regimes (Hildebrandt et al., 2011; Figure 2) as anabolic androgenic steroid use is not straightforward.

Steroids are typically utilised at steadily increasing doses, in the belief that ultimately much higher doses will be tolerated. "Pyramiding" regimes are a continuous sequence of increasing and decreasing doses; 27% of U.K. users employ "blast and cruise" regimes (Mcveigh et al., 2015; Sagoe et al., 2011); continuous "blasts" of high-dose anabolic androgenic steroid use interspersed with lower dose "cruise" periods. "Cruising" can still employ doses several times in excess of natural production (Bates & McVeigh, 2016). To deal with the significant side effects exceptionally high anabolic androgenic steroid doses are likely to produce, most user regimes incorporate recovery periods (Ip et al., 2014; Jespersen, 2012). Such regimes "cycle" through periods of administration and abstinence. The optimum cycle length is the subject of much user debate. The general guidelines suggest usage for 6 to 8 weeks (never more than 12) with an equal or longer off period (Llewellyn, 2011). Previously, it was found that most users were adhering to this guideline (Chandler & Mcveigh, 2013), but more recently, the average cycle length of U.K. Anabolic androgenic steroid users was found to be 20 weeks (Bates & McVeigh, 2016). This could



**FIGURE 2** Anabolic androgenic steroid (AAS) usage regimes with some examples of common polypharmacy

perhaps indicate an increase of younger users who are generally more reckless in terms of cycle length and dosages (Brennan et al., 2016).

### 8.1 | Anabolic androgenic steroids users and polypharmacy

It is believed by users, but never scientifically demonstrated, that combining different anabolic androgenic steroids, or ‘‘stacking,’’ will exert a synergistic effect on muscle growth; that is, the combined effects will be greater than the summed effects of each substance used individually. Stacking methods are increasing (Lood et al., 2012), with the vast majority of U.K. users combining both oral and injectable anabolic androgenic steroids (Chandler & McVeigh, 2013). Other potentially anabolic products, like human growth hormone or insulin, may also be included (Brennan et al., 2016; Chandler & McVeigh, 2013; Ip et al., 2011; Jespersen, 2012). Moreover, there are firm associations between anabolic androgenic steroids and use of other prescription or illicit drugs (Bates & McVeigh, 2016; Hakansson et al., 2012; Leifman et al., 2011), with extensive polypharmacy practised by many AAS users (Chandler & McVeigh, 2013; Ip et al., 2011; Ip et al., 2014; Lundholm et al., 2015).

Users incorporate, often numerous, substances into their regimes to prevent or self-treat a variety of side effects (Ip et al., 2011; Ip et al., 2014; Sagoe et al., 2015). They may also utilise other performance enhancing drugs to better define and enhance the aesthetic appearance of the musculature achieved by anabolic androgenic steroid (Sagoe et al., 2015). For example, fat-loss agents are increasingly popular (Jespersen, 2012). It is feared that the rapid results of combined anabolic androgenic steroid and fat-loss agent use are irresponsibly promoted within the anabolic androgen steroid community; 85%

of anabolic androgenic steroid users report incorporating a fat-loss agent (Hildebrandt et al., 2010), and 10% of U.K. AAS users declare use of life-threatening 2,4-dinitrophenol (Bates & McVeigh, 2016; Chandler & McVeigh, 2013).

### 9 | PSYCHIATRIC EFFECTS

The complex anabolic androgenic steroid regimes and likely polypharmacy adopted by users make studying and predicting behavioural changes in anabolic androgenic steroid users impossible. Administration of anabolic androgenic steroid compounds in animal studies and observations of human subjects displaying elevated levels of endogenous testosterone have predicted some of the behaviours expected in anabolic androgenic steroid abusers. Extreme anxiety, depression, irritability, increased aggression (“roid rage”; Heimly Jenssen & Johannessen, 2015; Lindqvist Bagge et al., 2017; Rowe, Berger, & Copeland, 2017), and violent behaviour (Advisory Council on the Misuse of Drugs, 2010; Lundholm et al., 2015) have emerged as common responses.

These are all behaviours for which neural transmission mediated by **GABA-type A** ( $\text{GABA}_\text{A}$ ) receptors in various regions of the basal forebrain play a pivotal role. Chronic exposure to anabolic androgenic steroids has been shown to alter  $\text{GABA}_\text{A}$  receptor subunit composition (Henderson et al., 2006); however, exploration of the effects of anabolic androgenic steroids on brain function is relatively new. The influence on pathways related to reproduction and sexual behaviour is most well known and studied (for review, see Clark & Henderson, 2003; Oberlander, Porter, Penatti, & Henderson, 2012). Investigation of other characteristics is complicated by the impact of environment, in addition to age and sex (McIntyre, Porter, & Henderson, 2002;

Oberlander et al., 2012). Shifts in emotion are more likely to be observed in response to specific environmental influences (threatening situations, availability of rewards like sex or drugs, etc.; Hildebrandt, Heywood, Wesley, & Schulz, 2018). Expressions of aggression and violence have been shown to be unpredictable and context dependent and generally only encountered when triggered by a stimulus (Kim & Wood, 2014; Wallin et al., 2015). Altered judgement pathways could make users' behaviours less flexible and unable to adapt to changing situations (Wallin & Wood, 2015). Similarly, naturally high testosterone levels have been correlated with reduced fear and diminished ability to empathise and make moral choices (Van Honk, Peper, & Schutter, 2005). The decision making process for affective behaviours is altered. These inabilities to modulate responses have serious consequences, such as increased incidence of violent offending (Lood et al., 2012) and intentional death (suicide/murder; Darke et al., 2014; Thiblin et al., 2015). However, this may be compounded by co-administration of other psychoactive substances (Lundholm et al., 2015). Especially as animal studies suggest that whilst anabolic androgenic steroid-induced aggression may be a characteristic of adolescent anabolic androgenic steroid use, anxiety is the more prominent attribute amongst adult users (Olivares et al., 2014; Rowe et al., 2017).

Anxiety has repeatedly been observed in animals exposed to anabolic androgenic steroid (Costine et al., 2010; Oberlander & Henderson, 2012; Olivares et al., 2014; Onakomaiya, Porter, Oberlander, & Henderson, 2014; Ricci, Morrison, & Melloni, 2012), and there is disproportionate diagnoses of anxiety disorders amongst anabolic androgenic steroid users (Ip et al., 2011). It is, therefore, surprising that long-term anabolic androgenic steroid use could actually have an anxiolytic effect in adults (Morrison, Ricci, & Melloni, 2015). This suggests that the anxiety experienced in adulthood could stem from an unrelated condition or it may be the result of anabolic androgenic steroid use in adolescence.

It is believed that adults experience aggression during anabolic androgenic steroid exposure and anxiety during withdrawal, relative to length of exposure (Lindqvist Bagge et al., 2017; Ricci, Morrison, & Melloni, 2013). It is difficult to ascertain whether anxiety drives AAS use or is a result of use. Just as it is not clear whether heightened aggression may be an underlying personality trait of anabolic androgenic steroid users, rather than an outcome of use (Heimly Jenssen & Johannessen, 2015). Aggression is only consistently observed with testosterone use and not significantly evidenced with other anabolic androgenic steroids (e.g. stanozolol may inhibit aggressive behaviours; Lumia & McGinnis, 2010; Tomlinson, Brown, & Hoaken, 2016). Testosterone, however, is thought to be the most popular anabolic androgenic steroid in use (Hildebrandt et al., 2010; McVeigh et al., 2015).

## 9.1 | Female anabolic androgenic steroid users

Initial work with female non-human subjects suggests that it is not possible to simply expect the same effects in female anabolic androgenic steroid users as male (Clark et al., 2006; Henderson et al., 2006).

Hormone signalling pathways change naturally with age, sex, and hormonal state. And there are sex-specific differences in endogenous hormones, hormone receptors, and expression of hormone-metabolising enzymes. Anabolic androgenic steroid treatment of mice indicated dose-dependent changes to the female brain that were not evident in males (Henderson et al., 2006).

Female subjects administered a relatively low dose of testosterone were found to be predisposed to antisocial behaviour (Van Honk & Schutter, 2007). This was due to the anabolic androgenic steroid significantly reducing their ability to detect threat (Van Honk & Schutter, 2007) and feel fear (Van Honk et al., 2005). This could provide some explanation as to why AAS use was found to be greater amongst females who had committed crime than females in general (Lundholm, Käll, Wallin, & Thiblin, 2010). What is not clear, however, is whether the increased criminal involvement could be a function of co-occurring poly-drug use (Lundholm et al., 2015).

## 9.2 | Adolescent anabolic androgenic steroid use

The adolescent brain, still in development, is more susceptible to negative effects of anabolic androgenic steroid use (Lumia & McGinnis, 2010; for review, see Clark & Henderson, 2003), which can change cell types and activity patterns within the hypothalamus (Morrison, Sikes, & Melloni, 2016). The adolescent brain is primed for steroid-dependent changes; thus, changes may occur which would not be seen in adult users (Henderson et al., 2006). Many of these changes are expected to be permanent (Clark et al., 2006). Even a single anabolic androgenic steroid administration in subjects so vulnerable to hormonal change could adversely affect cognitive processes such as learning and memory (Ramos-Pratts et al., 2013).

Effects on social behaviours most often recognised in animals were aggressive actions (Olivares et al., 2014; Rowe et al., 2017). This translates well to human activity. Adolescent boys who use anabolic androgenic steroids were consistently found to be engaged in more serious acts of aggression (e.g. burglary, rape, and/or use of weapons), and antisocial behaviour (e.g. criminality, bullying, and/or truancy), compared to those who use other illegal drugs or who have no substance abuse history (Hallgren et al., 2015). These findings also reflect the greater impairment of inhibition in adolescents compared to adult users (Hildebrandt et al., 2014). Some of the repercussions on social behaviours may not even be evident until adulthood, when anabolic androgenic steroid use has been discontinued (Olivares et al., 2014; Salas-Ramirez, Montalvo, & Sisk, 2010). Short-term exposure of male rats to anabolic androgenic steroids during adolescence was discerned to promote depressive or anxious-related behaviours in adulthood (Rainer et al., 2014).

AAS-induced changes have been found to be greater, and more likely to be permanent, in female adolescents (Clark et al., 2006). In young female users, anabolic androgen steroid use can influence onset of puberty and expression of sexual behaviours (Clark et al., 2006).

### 9.3 | Anabolic androgenic steroid use and cognitive impairment

There is very little data concerning active anabolic androgen steroid users and cognitive effects. Anabolic androgenic steroid use only became reasonably widespread throughout the late 80s and early 90s, and the long-term effects are therefore only now becoming discernible (Kanayama et al., 2013). One emerging complication is neurotoxicity. Experimental evidence supports that anabolic androgenic steroids permanently alter brain structure and function (Bjørnebekk et al., 2017; Caraci et al., 2011; Kanayama et al., 2013; Seitz et al., 2017; Westlye, Kaufmann, Alnæs, Hullstein, & Bjørnebekk, 2016) causing changes related to mental health and cognitive deficits (Westlye et al., 2016). The pathway of the neurodegeneration which results from anabolic androgenic steroids use is complex and little understood. What is known is that apoptotic mechanisms contribute, at least in part, to the pathophysiology (Pomara et al., 2015). Long-term high dosages of anabolic androgenic steroids may be linked with the onset of Alzheimer's disease (Kanayama et al., 2013; Kaufman et al., 2015). Long-term anabolic androgenic steroid users are not expected to have used the excessive doses in use today, in their early anabolic androgenic steroid careers. Yet a degree of brain damage has been demonstrated as reduced visuospatial learning and memory (Kanayama et al., 2013). As a "new" drug, most long-term users are not of an age at which cognitive dysfunction is perceptible.

### 10 | LIMITS OF THIS REVIEW

Whilst there are many accounts of the extreme popularity of anabolic androgenic steroids for image enhancement purposes (from users, medical professionals, needle exchanges, etc.), published research in support of such anecdotes is lacking. It is incredibly difficult to predict physiological and behavioural consequences of anabolic androgenic steroid abuse as these are now recognised to vary with anabolic androgenic steroid structure, metabolism and administration pattern (Clark et al., 2006; Henderson et al., 2006). The metabolites of designer anabolic androgenic steroids are not the same as the products that result from endogenous androgenic compounds. The interaction of such compounds with androgen and oestrogen receptors is not well documented, particularly at the concentrations associated with abuse (Henderson et al., 2006). Differing abundances and chemical structures may result in varied interactions with the neuroendocrine systems anabolic androgenic steroids have been shown to influence. This may help to explain some of the contradictory information arising from animal studies of behaviours related to depression and anxiety. Thus, the effects of each anabolic androgenic steroid must be studied individually. What is presented here can only provide a general overview of the more common anabolic androgenic steroids.

Furthermore, the majority of studies, both human and animal, focus on post-adolescent males. This has resulted in significant dearth of information and understanding of the physical and psychological ramifications of steroid use in adolescent and in particular female

users. In fact, the lack of studies on anabolic androgenic steroids, in comparison to other psychoactive drugs of abuse, may perpetuate the apparently false belief of "safeness" amongst users and policymakers.

Understanding how to tackle the problem of increasing anabolic androgenic steroid use is extremely difficult. There are many complex psychological and social routes to anabolic androgenic steroids use, many of which are not fully understood. There have been no studies to evidence successful interventions in relation to anabolic steroids. Currently, there are no formal academic evaluations of harm reduction, treatment, or prevention interventions in the United Kingdom or elsewhere (Petróczki, Dodge, Backhouse, & Adesanwo, 2014). However, usage patterns would suggest that interventions which focus on recreational gym users and target online supply might have greatest success.

### 11 | CONCLUSION

The true extent of anabolic androgenic steroid use in the United Kingdom is unknown but expanding. Data gathering on anabolic androgenic steroid use within the United Kingdom largely targets those with an online presence. Improvements are required to try and better represent others within the anabolic androgenic steroids using community, particularly those most at risk, females and adolescent boys. The specific anabolic androgenic steroid in common circulation are unknown but rely on user reports.

Anabolic androgenic steroids are very easily obtained, usually from online sources. As the use of health supplements has been strongly associated with anabolic androgenic steroid use, and these have been found to contain anabolic androgenic steroid substances, better regulation of this market could be beneficial, particularly as secondary school children are amongst the consumers. Further research is required in order to establish other potential triggers for anabolic androgenic steroid use in order to guide policymakers and public health initiatives to those most at risk.

The complexity of different usage patterns makes it extremely difficult to evaluate the negative effects of anabolic androgenic steroid use. This is further complicated by the strong association between anabolic androgenic steroid use and other drug misuse. AASs alter the behavioural effects and the rewarding properties of drugs of abuse and appear to be linked with addiction. The extent of polypharmacy now observed is troubling, as the toxicity of anabolic androgenic steroids when taken in combination with other substances is not known. The immediate dangers of anabolic androgenic steroid use appear to be the unreliability of composition and sterility of injectable products. The susceptibility of anabolic androgenic steroid users to blood-borne viruses needs to be addressed by targeting improved sexual behaviours.

Harm posed by anabolic androgenic steroids still cannot be fully assessed, although they do appear to be commensurate with aggression, violence, and criminality. As the long-term anabolic androgenic steroids using cohort reach maturity, further studies, with larger sample sizes, are required to investigate the potential for the severe

negative health effects associated with their use, particularly to the cardiovascular system, cerebrovascular, renal, and hepatic systems, and associated decreases in cognitive function.

## 11.1 | Nomenclature of targets and ligands

Key protein targets and ligands in this article are hyperlinked to corresponding entries in <http://www.guidetopharmacology.org>, the common portal for data from the IUPHAR/BPS Guide to PHARMACOLOGY (Harding et al., 2018), and are permanently archived in the Concise Guide to PHARMACOLOGY 2019/20 (Alexander et al., 2019a, 2019b).

## CONFLICT OF INTEREST

The authors declare no conflicts of interest.

## REFERENCES

- Abbate, V., Kicman, A. T., Evans-Brown, M., McVeigh, J., Cowan, D. A., Wilson, C., ... Walker, C. J. (2014). Anabolic steroids detected in body-building dietary supplements—A significant risk to public health. *Drug Testing and Analysis*, 7(7), 609–618. <https://doi.org/10.1002/dta.1728>
- Achar, S., Rostamian, A., & Narayan, S. M. (2010). Cardiac and metabolic effects of anabolic-androgenic steroid abuse on lipids, blood pressure, left ventricular dimensions, and rhythm. *American Journal of Cardiology*, 106(6), 893–901. <https://doi.org/10.1016/j.amjcard.2010.05.013>
- Advisory Council on the Misuse of Drugs, (2010). Consideration of the anabolic steroids.
- Alexander, S. P. H., Cidlowski, J. A., Kelly, E., Mathie, A., Peters, J. A., Veale, E. L., ... CGTP Collaborators. (2019a). The Concise Guide To Pharmacology 2019/20: Nuclear hormone receptors. *The British Journal of Pharmacology*, 176(S1), S229–S246.
- Alexander, S. P. H., Kelly, E., Mathie, A., Peters, J. A., Veale, E. L., Armstrong, J. F., ... CGTP Collaborators. (2019b). The Concise Guide To Pharmacology 2019/20: Transporters. *The British Journal of Pharmacology*, 176(S1), S397–S493.
- Alizade, E., Avcı, A., Fidan, S., Tabakçı, M., Bulut, M., Zehir, R., ... Akçakoyun, M. (2015). The effect of chronic anabolic-androgenic steroid use on Tp-E interval, Tp-E/Qt ratio, and Tp-E/Qtc ratio in male bodybuilders. *Annals of Noninvasive Electrocardiology: The Official Journal of the International Society for Holter and Noninvasive Electrocardiology, Inc*, 20(6), 592–600. <https://doi.org/10.1111/anec.12256>
- American Psychiatric Association, 2013. *Diagnostic and statistical manual of mental disorders (DSM-5)*,
- Angell, P., Chester, N., Green, D., Somauroo, J., Whyte, G., & George, K. (2012). Anabolic steroids and cardiovascular risk. *Sports Medicine*, 42(2), 119–134. <https://doi.org/10.2165/11598060-000000000-00000>
- Anon, 2015. Shooting up infections among people who inject drugs in the UK, 2014. Public Health England. Available at: [www.gov.uk/phe](http://www.gov.uk/phe) [Accessed August 18, 2016].
- Baggish, A. L., Weiner, R. B., Kanayama, G., Hudson, J. I., Lu, M. T., Hoffmann, U., & Pope H.G. Jr (2017). Cardiovascular toxicity of illicit anabolic-androgenic steroid use. *Circulation*, 135, 1991–2002. <https://doi.org/10.1161/CIRCULATIONAHA.116.026945>
- Baggish, A. L., Weiner, R. B., Kanayama, G., Hudson, J. I., Picard, M. H., Hutter AM Jr, & Pope H.G. Jr (2010). Long-term anabolic-androgenic steroid use is associated with left ventricular dysfunction. *Circulation: Heart Failure*, 3(4), 472–476. <https://doi.org/10.1161/CIRCHEARTFAILURE.109.931063>
- Bates, G. & McVeigh, J., 2016. Image and performance enhancing drugs 2015 survey results.
- Begley, E., McVeigh, J., Hope, V., Bates, G., Glass, R., Campbell, J., Smith, J. (2017). Image and performance enhancing drugs 2016 national survey results, Available at: [www.ljmu.ac.uk/phi](http://www.ljmu.ac.uk/phi) [Accessed November 7, 2019].
- Bhasin, S., Storer, T. W., Berman, N., Callegari, C., Clevenger, B., Phillips, J., ... Casaburi, R. (1996). The effects of supraphysiologic doses of testosterone on muscle size and strength in normal men. *The New England Journal of Medicine*, 335(1), 1–7. <https://doi.org/10.1056/NEJM199607043350101>
- Björk, T., Skärberg, K., & Engström, I. (2013). Eating disorders and anabolic androgenic steroids in males—Similarities and differences in self-image and psychiatric symptoms. *Substance Abuse Treatment, Prevention, and Policy*, 8, 30. <https://doi.org/10.1186/1747-597X-8-30>
- Bjørnebekk, A., Walhovd, K. B., Jørstad, M. L., Due-Tønnessen, P., Hullstein, I. R., & Fjell, A. M. (2017). Archival report structural brain imaging of long-term anabolic-androgenic steroid users and nonusing weightlifters. *Biological Psychiatry*, 82, 294–302. <https://doi.org/10.1016/j.biopsych.2016.06.017>
- Bolding, G., Sherr, L., Maguire, M., & Elford, J. (1999). HIV risk behaviours among gay men who use anabolic steroids. *Addiction*, 94(12), 1829–1835. <https://doi.org/10.1046/j.1360-0443.1999.941218298.x>
- Booth, A., Johnson, D. R., & Granger, D. A. (1999). Testosterone and men's health. *Journal of Behavioral Medicine*, 22(1), 1–19.
- Börjesson, A., Gårevik, N., Dahl, M. L., Rane, A., & Ekström, L. (2016). Recruitment to doping and help-seeking behavior of eight female AAS users. *Substance Abuse Treatment, Prevention, and Policy*, 11, 11. <https://doi.org/10.1186/s13011-016-0056-3>
- Brennan, R., Wells, J. S., & Van Hout, M.-C. (2016). The injecting use of image and performance-enhancing drugs (IPED) in the general population: A systematic review. *Health & Social Care in the Community*, 25(5), 1459–1531. <https://doi.org/10.1111/hsc.12326>
- Caraci, F., Pistarà, V., Corsaro, A., Tomasello, F., Giuffrida, M. L., Sortino, M. A., ... Copani, A. (2011). Neurotoxic properties of the anabolic androgenic steroids nandrolone and methandrostenolone in primary neuronal cultures. *Journal of Neuroscience Research*, 89, 592–600. <https://doi.org/10.1002/jnr.22578>
- Chahla, E., Hammami, M. B., & Befeler, A. S. (2014). Hepatotoxicity associated with anabolic androgenic steroids present in over-the-counter supplements: A case series. *International Journal of Applied Science and Technology*, 4(3), 179–183.
- Chandler, M. & McVeigh, J., 2013. Steroids and image enhancing drugs 2013 survey results.
- Clark, A. S., Costine, B. A., Jones, B. L., Kelton-Rehkopf, M. C., Meerts, S. H., Nutbrown-Greene, L. L., ... Henderson, L. P. (2006). Sex- and age-specific effects of anabolic androgenic steroids on reproductive behaviors and on GABAergic transmission in neuroendocrine control regions. *Brain Research*, 1126(1), 122–138. <https://doi.org/10.1016/j.brainres.2006.08.081>
- Clark, A. S., & Henderson, L. P. (2003). Behavioral and physiological responses to anabolic-androgenic steroids. *Neuroscience and Biobehavioral Reviews*, 27, 416–436.
- Coomber, R., Pavlidis, A., Santos, G. H., Wilde, M., Schmidt, W., & Redshaw, C. (2014). The supply of steroids and other performance and image enhancing drugs (PIEDs) in one English city: Fakes, counterfeits, supplier trust, common beliefs and access. *Performance Enhancement & Health*, 3, 135–144. <https://doi.org/10.1016/j.peh.2015.10.004>
- Cooper, I., Reeve, N., & Doherty, W. (2011). Delayed diagnosis of a cerebrovascular accident associated with anabolic steroid use. *BMJ Case Reports*, 2011, 1–4.
- Cordaro, F. G., Lombardo, S., & Cosentino, M. (2011). Selling androgenic anabolic steroids by the pound: Identification and analysis of popular

- websites on the Internet. *Scandinavian Journal of Medicine and Science in Sports*, 21(6), 247–259.
- Cornford, C. S., Kean, J., & Nash, A. (2014). Anabolic-androgenic steroids and heroin use: A qualitative study exploring the connection. *International Journal of Drug Policy*, 25, 928–930. <https://doi.org/10.1016/j.drugpo.2014.06.002>
- Costine, B. A., Oberlander, J. G., Davis, M. C., Penatti, C. A., Porter, D. M., Leaton, R. N., & Henderson, L. P. (2010). Chronic anabolic androgenic steroid exposure alters corticotropin releasing factor expression and anxiety-like behaviors in the female mouse. *Psychoneuroendocrinology*, 35, 1473–1485. <https://doi.org/10.1016/j.psyneuen.2010.04.015>
- da Justa Neves, D. B., Marchetti, R. G. A., & Caldas, E. D. (2013). Incidence of anabolic steroid counterfeiting in Brazil. *Forensic Science International*, 228(1–3), 81–84.
- Darke, S., Torok, M., & Duflou, J. (2014). Sudden or unnatural deaths involving anabolic-androgenic steroids. *Journal of Forensic Sciences*, 59(4), 1025–1028.
- de Moura Ribeiro, M. V., Boralle, N., Felippe, L. G., Pezza, H. R., & Pezza, L. (2018). 1H NMR determination of adulteration of anabolic steroids in seized drugs. *Steroids*, 138, 47–56.
- Dunn, M., McKay, F. H., & Iversen, J. (2014). Steroid users and the unique challenge they pose to needle and syringe program (NSP) workers. *Health & Social Care in the Community*, 25(5), 71–77.
- Dynamic Sports Nutrition. (2016). Anabolics.com, The Advanced Science of Muscle Building. Available at: <https://www.steroids.com> [Accessed June 20, 2010].
- Eisenberg, M. E., Wall, M., & Neumark-Sztainer, D. (2012). Muscle-enhancing behaviors among adolescent girls and boys. *Pediatrics*, 130(6), 1019–1026. <https://doi.org/10.1542/peds.2012-0095>
- El Osta, R., Almont, T., Diligent, C., Hubert, N., Eschwège, P., & Hubert, J. (2016). Anabolic steroids abuse and male infertility. *Basic and Clinical Andrology*, 26, 2. <https://doi.org/10.1186/s12610-016-0029-4>
- El Sherrif, Y., Potts, J. R., Howard, M. R., Barnardo, A., Cairns, S., Knisely, A. S., & Verma, S. (2013). Hepatotoxicity from anabolic androgenic steroids marketed as dietary supplements: Contribution from ATP8B1/ABCB11 mutations? *Liver International*, 33(8), 1266–1270. <https://doi.org/10.1111/liv.12216>
- Elsharkawy, A. M., McPherson, S., Masson, S., Burt, A. D., Dawson, R. T., & Hudson, M. (2012). Lesson of the week: Cholestasis secondary to anabolic steroid use in young men. *British Medical Journal*, 344, e468. <https://doi.org/10.1136/bmj.e468>
- Evans, N. A. (1997). Local complications of self administered anabolic steroids. *British Journal of Sports Medicine*, 31(4), 349–350. <https://doi.org/10.1136/bjsm.31.4.349>
- Frankenfeld, S. P., Oliveira, L. P., Ortenzi, V. H., Rego-Monteiro, I. C. C., Chaves, E. A., Ferreira, A. C., ... Fortunato, R. S. (2014). The anabolic androgenic steroid nandrolone decanoate disrupts redox homeostasis in liver, heart and kidney of male Wistar rats. *PLoS ONE*, 9(9), e102699. <https://doi.org/10.1371/journal.pone.0102699>
- Fuller, E., Hawkins, V. (2013). Smoking, drinking and drug use among young people in England in 2012, Health and Social Care Information Centre. Available at: <http://www.hscic.gov.uk/catalogue/PUB11334/smok-drin-drug-youn-peop-eng-2012-repo.pdf>.
- Graham, M. R., Ryan, P., Baker, J. S., Davies, B., Thomas, N. E., Cooper, S. M., ... Kicman, A. T. (2009). Counterfeiting in performance- and image-enhancing drugs. *Drug Testing and Analysis*, 1(1), 135–142. <https://doi.org/10.1002/dta.30>
- Griffiths, S., Murray, S. B., & Mond, J. M. (2016). The stigma of anabolic steroid use. *Journal of Drug Issues*, 46(4), 446–456. <https://doi.org/10.1177/0022042616661837>
- Hakansson, A., Mickelsson, K., Wallin, C., & Berglund, M. (2012). Anabolic androgenic steroids in the general population: User characteristics and associations with substance use. *European Addiction Research*, 18, 83–90. <https://doi.org/10.1159/000333037>
- Hallgren, M., Pope H.G. Jr, Kanayama, G., Hudson, J. I., Lundin, A., & Källmén, H. (2015). Anti-social behaviors associated with anabolic-androgenic steroid use among male adolescents. *European Addiction Research*, 21, 321–326. <https://doi.org/10.1159/000433580>
- Hanley Santos, G., & Coomber, R. (2017). The risk environment of anabolic-androgenic steroid users in the UK: Examining motivations, practices and accounts of use. *International Journal of Drug Policy*, 40, 35–43.
- Harding, S., Sharman, J. L., Faccenda, E., Southan, C., Pawson, A. J., Ireland, S., ... Davies, J. A. (2018). The IUPHAR/BPS Guide to PHARMACOLOGY in 2018: updates and expansion to encompass the new guide to IMMUNOPHARMACOLOGY. *Nucleic Acids Research*, 46(1), D1091–D1106.
- Harrington, P., Ali, G., & Chan, A. (2011). The development of focal segmental glomerulosclerosis secondary to anabolic steroid abuse. *BMJ Case Reports*, 2011, bcr0720114531. <https://doi.org/10.1136/bcr.07.2011.4531>
- Heimly Jenssen, I., & Johannessen, K. B. (2015). Aggression and body image concerns among anabolic androgenic steroid users, contemplators, and controls in Norway. *Body Image*, 12, 6–13.
- Henderson, L. P., Penatti, C. A., Jones, B. L., Yang, P., & Clark, A. S. (2006). Anabolic androgenic steroids and forebrain GABAergic transmission. *Neuroscience*, 138, 793–799. <https://doi.org/10.1016/j.neuroscience.2005.08.039>
- Henrique, S., Da, A., & Junior, S. (2013). Hospital morbidity due to anabolic-androgenic steroids (AAS) consumption in Brazil. *Revista Brasileira de Medicina do Esporte*, 19(2), <https://doi.org/10.1590/S1517-86922013000200007>
- Hildebrandt, T., Alfano, L., & Langenbucher, J. W. (2010). Body image disturbance in 1000 male appearance and performance enhancing drug users. *Journal of Psychiatric Research*, 44, 841–846.
- Hildebrandt, T., Harty, S., & Langenbucher, J. W. (2012). Fitness supplements as a gateway substance for anabolic-androgenic steroid use. *Psychology of Addictive Behaviours*, 26(4), 955–962.
- Hildebrandt, T., Heywood, A., Wesley, D., & Schulz, K. (2018). Defining the construct of synthetic androgen intoxication: An application of general brain arousal. *Frontiers in Psychology*, 9(MAR), 1–11.
- Hildebrandt, T., Langenbucher, J. W., Flores, A., Harty, S., & Berlin, H. A. (2014). The influence of age of onset and acute anabolic steroid exposure on cognitive performance, impulsivity, and aggression in men. *Psychology of Addictive Behaviors*, 28(4), 1096–1104. <https://doi.org/10.1037/a0036482>
- Hildebrandt, T., Langenbucher, J. W., Lai, J. K., Loeb, K. L., & Hollander, E. (2011). Development and validation of the appearance and performance enhancing drug use schedule. *Addictive Behaviors*, 36, 949–958. <https://doi.org/10.1016/j.addbeh.2011.05.002>
- Home Office. (2015). Drug misuse: Findings from the 2014/15 crime survey for England and Wales second edition,
- Home Office. (2018). Drug misuse: Findings from the 2017/18 crime survey for England and Wales
- Hope, V. D., Harris, R., McVeigh, J., Cullen, K. J., Smith, J., Parry, J. V., ... Ncube, F. (2016). Risk of HIV and hepatitis B and C over time among men who inject image and performance enhancing drugs in England and Wales: Results from cross-sectional prevalence surveys, 1992–2013. *Journal of Acquired Immune Deficiency Syndromes*, 71(3), 331–337. <https://doi.org/10.1097/QAI.0000000000000835>
- Hope, V. D., McVeigh, J., Marongiu, A., Evans-Brown, M., Smith, J., Kimergård, A., ... Ncube, F. (2013). Prevalence of, and risk factors for, HIV, hepatitis B and C infections among men who inject image and performance enhancing drugs: A cross-sectional study. *BMJ Open*, 3(9), e003207. <https://doi.org/10.1136/bmjopen-2013-003207>

- Hope, V. D., McVeigh, J., Marongiu, A., Evans-Brown, M., Smith, J., Kimergård, A., ... Ncube, F. (2014). Injection site infections and injuries in men who inject image- and performance-enhancing drugs: Prevalence, risks factors, and healthcare seeking. *Epidemiology and Infection*, 143(1), 132–140. <https://doi.org/10.1017/S0950268814000727>
- Hope, V. D., McVeigh, J., Smith, J., Glass, R., Njoroge, J., Tanner, C., ... Desai, M. (2017). Low levels of hepatitis C diagnosis and testing uptake among people who inject image and performance enhancing drugs in England and Wales, 2012–15. *Drug and Alcohol Dependence*, 179, 83–86. <https://doi.org/10.1016/j.drugalcdep.2017.06.018>
- House of Commons Science and Technology Committee (2006). *Drug classification: Making a hash of it? Fifth report of session 2005–06*. Great Britain: Parliament; House of Commons.
- Ip, E. J., Barnett, M. J., Tenerowicz, M. J., & Perry, P. J. (2011). The Anabolic 500 survey: Characteristics of male users versus nonusers of anabolic-androgenic steroids for strength training. *Pharmacotherapy*, 31(8), 757–766. <http://www.ncbi.nlm.nih.gov/pubmed/21923602>, <https://doi.org/10.1592/phco.31.8.757>
- Ip, E. J., Lu, D. H., Barnett, M. J., Tenerowicz, M. J., Vo, J. C., & Perry, P. J. (2012). Psychological and physical impact of anabolic-androgenic steroid dependence. *Pharmacotherapy*, 32(10), 910–919. <https://doi.org/10.1002/j.1875-9114.2012.01123>
- Ip, E. J., Trinh, K., Tenerowicz, M. J., Pal, J., Lindfelt, T. A., & Perry, P. J. (2014). Characteristics and behaviors of older male anabolic steroid users. *Journal of Pharmacy Practice*, 28(March), 450–456.
- Jampel, J. D., Murray, S. B., Griffiths, S., & Blashill, A. J. (2016). Self-perceived weight and anabolic steroid misuse among US adolescent boys. *Journal of Adolescent Health*, 58, 397–402. <https://doi.org/10.1016/j.jadohealth.2015.10.003>
- Jespersen, M. R. (2012). "Definitely not for women": An online community's reflections on women's use of performance enhancing drugs in recreational sports. *Athletic Enhancement, Human Nature and Ethics, International Library of Ethics, Law and New Medicine*, 52, 201–218.
- Kailanto, S., Kankaanpää, A., & Seppälä, T. (2011). Subchronic steroid administration induces long lasting changes in neurochemical and behavioral response to cocaine in rats. *Steroids*, 76(12), 1310–1316.
- Kanayama, G., Brower, K. J., Wood, R. I., Hudson, J. I., & Pope HG Jr (2009). Anabolic-androgenic steroid dependence: An emerging disorder. *Addiction*, 104(12), 1966–1978. <https://doi.org/10.1111/j.1360-0443.2009.02734.x>
- Kanayama, G., Brower, K. J., Wood, R. I., Hudson, J. I., & Pope Jr, H. G. (2010). Treatment of anabolic-androgenic steroid dependence: Emerging evidence and its implications. *Drug and Alcohol Dependence*, 109, 6–13. <https://doi.org/10.1016/j.drugalcdep.2010.01.011>
- Kanayama, G., Hudson, J. I., DeLuca, J., Isaacs, S., Baggish, A., Weiner, R., ... Pope HG Jr (2015). Prolonged hypogonadism in males following withdrawal from anabolic-androgenic steroids: An under-recognized problem. *Addiction*, 110(5), 823–831. <https://doi.org/10.1111/add.12850>
- Kanayama, G., Kean, J., Hudson, J. I., & Pope, H. G. Jr. (2013). Cognitive deficits in long-term anabolic-androgenic steroid users. *Drug and Alcohol Dependence*, 130, 208–214. <https://doi.org/10.1016/j.drugalcdep.2012.11.008>
- Kaufman, M. J., Janes, A. C., Hudson, J. I., Brennan, B. P., Kanayama, G., Kerrigan, A. R., ... Pope, H. G. Jr. (2015). Brain and cognition abnormalities in long-term anabolic-androgenic steroid users. *Drug and Alcohol Dependence*, 152, 47–56. <https://doi.org/10.1016/j.drugalcdep.2015.04.023>
- Kim, J. Y., & Wood, R. I. (2014). Anabolic-androgenic steroids and appetitive sexual behavior in male rats. *Hormones and Behavior*, 66, 585–590.
- Kimergård, A., & McVeigh, J. (2014). Variability and dilemmas in harm reduction for anabolic steroid users in the UK: A multi-area interview study. *Harm Reduction Journal*, 11, 19. <https://doi.org/10.1186/1477-7517-11-19>
- Kurling-Kailanto, S., Kankaanpää, A., & Seppälä, T. (2010). Subchronic nandrolone administration reduces cocaine-induced dopamine and 5-hydroxytryptamine outflow in the rat nucleus accumbens. *Psychopharmacology*, 209(189), 271–281.
- Leifman, H., Rehnman, C., Sjöblom, E., & Holgersson, S. (2011). Anabolic androgenic steroids—Use and correlates among gym users—An assessment study using questionnaires and observations at gyms in the Stockholm region. *International Journal of Environmental Research and Public Health*, 8, 2656–2674. <https://doi.org/10.3390/ijerph8072656>
- Lindqvist Bagge, A. S., Rosén, T., Fahlke, C., Ehrnborg, C., Eriksson, B. O., Moberg, T., & Thiblin, I. (2017). Somatic effects of AAS abuse: A 30-years follow-up study of male former power sports athletes. *Journal of Science and Medicine in Sport*, 20(9), 814–818. <https://doi.org/10.1016/j.jsams.2017.03.008>
- Llewellyn, W. (2011). *William Llewellyn's anabolics* (10th ed.). Jupiter, FL: Molecular Nutrition.
- Lood, Y., Eklund, A., Garle, M., & Ahlner, J. (2012). Anabolic androgenic steroids in police cases in Sweden 1999–2009. *Forensic Science International*, 219, 199–204. <https://doi.org/10.1016/j.forsciint.2012.01.004>
- Lorang, M., Callahan, B., Cummins, K. M., Achar, S., & Brown, S. A. (2011). Anabolic androgenic steroid use in teens: Prevalence, demographics, and perception of effects. *Journal of Child & Adolescent Substance Abuse*, 20(4), 358–369. <https://doi.org/10.1080/1067828X.2011.598842>
- Lumia, A. R., & McGinnis, M. Y. (2010). Impact of anabolic androgenic steroids on adolescent males. *Physiology & Behavior*, 100, 199–204. <https://doi.org/10.1016/j.physbeh.2010.01.007>
- Lundholm, L., Frisell, T., Lichtenstein, P., & Långström, N. (2015). Anabolic androgenic steroids and violent offending: Confounding by polysubstance abuse among 10365 general population men. *Addiction*, 110(1), 100–108. <https://doi.org/10.1111/add.12715>
- Lundholm, L., Käll, K., Wallin, S., & Thiblin, I. (2010). Use of anabolic androgenic steroids in substance abusers arrested for crime. *Drug and Alcohol Dependence*, 111, 222–226. <https://doi.org/10.1016/j.drugalcdep.2010.04.020>
- Lusetti, M., Licata, M., Silingardi, E., Reggiani Bonetti, L., & Palmiere, C. (2015). Pathological changes in anabolic androgenic steroid users. *Journal of Forensic and Legal Medicine*, 33, 101–104. <https://doi.org/10.1016/j.jflm.2015.04.014>
- Maior, A. S., Menezes, P., Pedrosa, R. C., Carvalho, D. P., Soares, P. P., & Nascimento, J. H. M. (2010). Abnormal cardiac repolarization in anabolic androgenic steroid users carrying out submaximal exercise testing. *Clinical and Experimental Pharmacology and Physiology*, 37(12), 1129–1133. <https://doi.org/10.1111/j.1440-1681.2010.05452.x>
- Martins, R. A., Gomes, G. A., Aguiar O Jr, Medalha, C. C., & Ribeiro, D. A. (2010). Chromosome damage and cytotoxicity in oral mucosa cells after 2 months of exposure to anabolic steroids (decadurabolin and winstrol) in weight lifting. *Steroids*, 75, 952–955. <https://doi.org/10.1016/j.steroids.2010.05.015>
- Marusich, J. A., Craft, R. M., Lefever, T. W., & Wiley, J. L. (2015). The impact of gonadal hormones on cannabinoid dependence. *Experimental and Clinical Psychopharmacology*, 23(4), 206–216. <https://doi.org/10.1037/pha0000027>
- McDonald, C. L., Marlowe, D. B., Patapis, N. S., Festinger, D. S., & Forman, R. F. (2012). Nonprescription steroids on the Internet. *Substance use & Misuse*, 47(3), 329–341.
- McIntyre, K. L., Porter, D. M., & Henderson, L. P. (2002). Anabolic androgenic steroids induce age-, sex-, and dose-dependent changes in GABA<sub>A</sub> receptor subunit mRNAs in the mouse forebrain. *Neuropharmacology*, 43, 634–645.
- McVeigh, J., Bates, G., & Chandler, M. (2015). Steroids and image enhancing drugs 2014 survey results.
- Mhillaj, E., Morgese, M. G., Tucci, P., Bove, M., Schiavone, S., & Trabace, L. (2015). Effects of anabolic-androgens on brain reward function. *Frontiers in Neuroscience*, 9(AUG), 1–13.

- Molero, Y., Bakshi, A.-S., & Gripenberg, J. (2017). Illicit drug use among gym-goers: A cross-sectional study of gym-goers in Sweden. *Sports Medicine*, 3, 31. <https://doi.org/10.1186/s40798-017-0098-8>
- Montisci, M., El-Mazloum, R., Cecchetto, G., Terranova, C., Ferrara, S. D., Thiene, G., & Bassi, C. (2011). Anabolic androgenic steroids abuse and cardiac death in athletes: Morphological and toxicological findings in four fatal cases. *Forensic Science International*, 217, e12-e17.
- Morrison, T. R., Ricci, L. A., & Melloni, R. H. (2015). Anabolic/androgenic steroid administration during adolescence and adulthood differentially modulates aggression and anxiety. *Hormones and Behavior*, 69, 132–138. <https://doi.org/10.1016/j.yhbeh.2015.01.009>
- Morrison, T. R., Sikes, R. W., & Melloni, A. R. H. (2016). Anabolic steroids alter the physiological activity of aggression circuits in the lateral anterior hypothalamus. *Neuroscience*, 315, 1–17. <https://doi.org/10.1016/j.neuroscience.2015.12.001>
- Murray, S. B., Griffiths, S., Mond, J. M., Kean, J., & Blashill, A. J. (2016). Anabolic steroid use and body image psychopathology in men: Delinquent between appearance- versus performance-driven motivations. *Drug and Alcohol Dependence*, 165, 198–202. <https://doi.org/10.1016/j.drugalcdep.2016.06.008>
- National Institute on Drug Abuse. (2007). The neurobiology of drug addiction.
- NHS England. (2019). Open prescribing. 6.4.2 Male sex hormones and antagonists. Available at: <https://openprescribing.net/bnf/060402/> [Accessed May 30, 2019].
- NHS Scotland. (2014). Scottish Schools Adolescent Lifestyle and Substance Use Survey 2013.
- NHS Scotland Information Services Division. (2016). Injecting Equipment Provision in Scotland 2014/15.
- NHS Scotland Information Services Division. (2018). Injecting Equipment Provision in Scotland 2016/17.
- Nieschlag, E., & Vorona, E. (2015). Doping with anabolic androgenic steroids (AAS): Adverse effects on non-reproductive organs and functions. *Reviews in Endocrine & Metabolic Disorders*, 16, 199–211.
- Nøkleby, H., & Skárderud, F. (2013). Body practices among male drug abusers. Meanings of workout and use of doping agents in a drug treatment setting. *International Journal of Mental Health and Addiction*, 11, 490–502.
- Nutt, D. J., King, L. A., & Phillips, L. D. (2010). Drug harms in the UK: A multicriteria decision analysis. *The Lancet*, 376(9752), 1558–1565.
- Oberlander, J. G., & Henderson, L. P. (2012). Corticotropin-releasing factor modulation of forebrain GABAergic transmission has a pivotal role in the expression of anabolic steroid-induced anxiety in the female mouse. *Neuropharmacology*, 57(10), 1483–1499.
- Oberlander, J. G., Porter, D. M., Penatti, C. A. A., & Henderson, L. P. (2012). Anabolic androgenic steroid abuse: Multiple mechanisms of regulation of GABAergic synapses in neuroendocrine control regions of the rodent forebrain. *Journal of Neuroendocrinology*, 24(1), 202–214. <https://doi.org/10.1111/j.1365-2826.2011.02151.x>
- Olivares, E. L., Silveira, A. L., Fonseca, F. V., Silva-Almeida, C., Côrtes, R. S., Pereira-Junior, P. P., ... Reis, L. C. (2014). Administration of an anabolic steroid during the adolescent phase changes the behavior, cardiac autonomic balance and fluid intake in male adult rats. *Physiology & Behavior*, 126, 15–24. <https://doi.org/10.1016/j.physbeh.2013.12.006>
- Onakomaiyi, M. M., Porter, D. M., Oberlander, J. G., & Henderson, L. P. (2014). Sex and exercise interact to alter the expression of anabolic androgenic steroid-induced anxiety-like behaviors in the mouse. *Hormones and Behavior*, 66, 283–297. <https://doi.org/10.1016/j.yhbeh.2014.04.008>
- Pai, R., Parampalli, U., Hettiarachchi, G., & Ahmed, I. (2013). Mycobacterium fortuitum skin infection as a complication of anabolic steroids: A rare case report. *The Annals of the Royal College of Surgeons of England*, 95(95), 12–13.
- Parker, H., Williams, L., & Aldridge, J. (2002). The normalization of "sensible" recreational drug use: Further evidence from the North West England longitudinal study. *Sociology*, 36(4), 941–964.
- Perera, N. J., Steinbeck, K. S., & Shackel, N. (2013). The adverse health consequences of the use of multiple performance-enhancing substances—A deadly cocktail. *The Journal of Clinical Endocrinology and Metabolism*, 198(12), 4613–4618.
- Petróczki, A., Dodge, T., Backhouse, S., & Adesano, C. (2014). Review of the literature on negative health risks based interventions to guide anabolic steroid misuse prevention. *Performance and Enhancement Health*, 3(1), 31–44. <https://doi.org/10.1016/j.peh.2014.08.001>
- Pomara, C., Neri, M., Bello, S., Fiore, C., Riezzo, I., & Turillazzi, E. (2015). Neurotoxicity by synthetic androgen steroids: Oxidative stress, apoptosis, and neuropathology: A review. *Current Neuropharmacology*, 13, 132–145. <https://doi.org/10.2174/1570159X13666141210221434>
- Pope, H. G., Kanayama, G., & Hudson, J. I. (2012). Risk factors for illicit anabolic-androgenic steroid use in male weightlifters: A cross-sectional cohort study. *Biological Psychiatry*, 71, 254–261. <https://doi.org/10.1016/j.biopsych.2011.06.024>
- Prendergast, H. M., Bannen, T., Erickson, T. B., & Honore, K. R. (2003). The toxic torch of the modern olympic games. *Veterinary and Human Toxicology*, 45(2), 97–102.
- Radcliffe, P., & Stevens, A. (2008). Are drug treatment services only for "thieving junkie scumbags"? Drug users and the management of stigmatised identities. *Social Science and Medicine*, 67, 1065–1073. <https://doi.org/10.1016/j.socscimed.2008.06.004>
- Rainer, Q., Speziali, S., Rubino, T., Dominguez-Lopez, S., Bambico, F. R., Gobbi, G., & Parolari, D. (2014). Chronic nandrolone decanoate exposure during adolescence affects emotional behavior and monoaminergic neurotransmission in adulthood. *Neuropharmacology*, 83, 79–88. <https://doi.org/10.1016/j.neuropharm.2014.03.015>
- Ramos-Pratts, K., Rosa-González, D., Pérez-Acevedo, N. L., Cintrón-López, D., & Barreto-Estrada, J. L. (2013). Sex-specific effect of the anabolic steroid, 17 $\alpha$ -methyltestosterone, on inhibitory avoidance learning in periadolescent rats. *Behavioural Processes*, 99, 33–80.
- Ravn, S., & Coffey, J. (2016). "Steroids, it's so much an identity thing!" perceptions of steroid use, risk and masculine body image. *Journal of Youth Studies*, 19(1), 87–102.
- Reza, H., Ågren, G., & Thiblin, I. (2012). Cardiac hypertrophy in deceased users of anabolic androgenic steroids: An investigation of autopsy findings. *Cardiovascular Pathology*, 21, 312–316.
- Ricci, L. A., Morrison, T. R., & Melloni, R. H. (2012). Serotonin modulates anxiety-like behaviors during withdrawal from adolescent anabolic-androgenic steroid exposure in Syrian hamsters. *Hormones and Behavior*, 62, 569–578. <https://doi.org/10.1016/j.yhbeh.2012.09.007>
- Ricci, L. A., Morrison, T. R., & Melloni, R. H. (2013). Adolescent anabolic-androgenic steroids: Aggression and anxiety during exposure predict behavioral responding during withdrawal in Syrian hamsters (*Mesocricetus auratus*). *Hormones and Behavior*, 64(5), 770–780.
- Robles-Díaz, M., González-Jiménez, A., Medina-Caliz, I., Stephens, C., García-Cortés, M., García-Muñoz, B., ... SLatinDILI Network (2015). Distinct phenotype of hepatotoxicity associated with illicit use of anabolic androgenic steroids. *Alimentary Pharmacology and Therapeutics*, 41(1), 116–125. <https://doi.org/10.1111/apt.13023>
- Rothman, R. D., Weiner, R. B., Pope, H., Kanayama, G., Hutter, A. M., Fifor, M. A., ... Baggish, A. L. (2011). Anabolic androgenic steroid induced myocardial toxicity: An evolving problem in an aging population. *British Medical Journal Case Reports*.
- Rowe, R., Berger, I., & Copeland, J. (2017). No pain, no gainz? Performance and image-enhancing drugs, health effects and information seeking. *Drugs Educ Prev Pol*, 24(5), 400–408.
- Russo, R., Marks, N., Morris, K., King, H., Gelvin, A., & Rooney, R. (2012). Life-threatening necrotizing fasciitis due to "bath salts" injection. *Orthopedics*, 35(1), 124–127.

- Sagoe, D., McVeigh, J., Bjørnebekk, A., Essilfie, M. S., Andreassen, C. S., & Pallesen, S. (2011). Polypharmacy among anabolic-androgenic steroid users: A descriptive metasynthesis. *Substance Abuse Treatment, Prevention, and Policy*, 10(12), <https://doi.org/10.1186/s13011-015-0006-5>
- Sagoe, D., Torsheim, T., Molde, H., Andreassen, C. S., & Pallesen, S. (2015). Anabolic-androgenic steroid use in the Nordic countries: A meta-analysis and meta-regression analysis. *Nordic Studies on Alcohol and Drugs*, 32, 7–20. <https://doi.org/10.1515/nsad-2015-0002>
- Salas-Ramirez, K. Y., Montalvo, P. R., & Sisk, C. L. (2010). Anabolic steroids have long-lasting effects on male social behaviors. *Behavioural Brain Research*, 208, 328–335. <https://doi.org/10.1016/j.bbr.2009.11.026>
- Seitz, J., Lyall, A. E., Kanayama, G., Makris, N., Hudson, J. I., Kubicki, M., ... Kaufman, M. J. (2017). White matter abnormalities in long-term anabolic-androgenic steroid users: A pilot study. *Psychiatry Research: Neuroimaging*, 260, 1–5. <https://doi.org/10.1016/j.psychresns.2016.12.003>
- Shamloul, R. M., Aborayah, A. F., Hashad, A., & Abd-Allah, F. (2014). Anabolic steroids abuse-induced cardiomyopathy and ischaemic stroke in a young male patient. *Case Reports*, 2014(1), <http://dx.doi.org/10.1136/bcr-2013-203033>
- Shimada, Y., Yoritaka, A., Tanaka, Y., Miyamoto, N., Ueno, Y., Hattori, N., & Takao, U. (2012). Cerebral infarction in a young man using high-dose anabolic steroids. *Journal of Stroke and Cerebrovascular Diseases*, 21, 906.e9–906.e11.
- Simões Tanasov, V., Neto, W. K., Gonçalves, L., Maifrino, L. B., de Sousa, R. R., & Gama, E. F. (2014). Use of anabolic steroid altered the liver morphology of rats. *International Journal of Morphology*, 32(3), 756–760. <https://doi.org/10.4067/S0717-95022014000300002>
- Struik, D., Fadda, P., Zara, T., Zamberletti, E., Rubino, T., Parolario, D., ... Fattore, L. (2017). The anabolic steroid nandrolone alters cannabinoid self-administration and brain CB1 receptor density and function. *Pharmacological Research*, 115, 209–217. <https://doi.org/10.1016/j.phrs.2016.11.031>
- Struik, D., Sanna, F., & Fattore, L. (2018). The modulating role of sex and anabolic-androgenic steroid hormones in cannabinoid sensitivity. *Frontiers in Behavioural Neuroscience*, 12, 249. <https://doi.org/10.3389/fnbeh.2018.00249>
- The Scottish Government. (2010). Guidelines for services providing injecting equipment: Best practice recommendations for commissioners and injecting equipment provision (IEP) services in Scotland.
- Thiblin, I., Garmo, H., Garle, M., Holmberg, L., Byberg, L., Michaëllsson, K., & Gedeborg, R. (2015). Anabolic steroids and cardiovascular risk: A national population-based cohort study. *Drug and Alcohol Dependence*, 152, 87–92. <https://doi.org/10.1016/j.drugalcdep.2015.04.013>
- Tomlinson, M. F., Brown, M., & Hoaken, P. N. S. (2016). Recreational drug use and human aggressive behavior: A comprehensive review since 2003. *Aggression and Violent Behaviour*, 27, 9–29.
- Van Beek, I., & Chronister, K. J. (2015). Performance and image enhancing drug injectors' access to needle syringe programs: Responding to a public policy dilemma. *International Journal of Drug Policy*, 26, 868–874. <https://doi.org/10.1016/j.drugpo.2015.05.009>
- Van Honk, J., Peper, J. S., & Schutter, D. J. L. G. (2005). Testosterone reduces unconscious fear but not consciously experienced anxiety: Implications for the disorders of fear and anxiety. *Biological Psychiatry*, 58, 218–225. <https://doi.org/10.1016/j.biopsych.2005.04.003>
- Van Honk, J., & Schutter, D. J. L. G. (2007). Testosterone reduces conscious detection of signals serving social correction implications for antisocial behavior. *Psychological Science*, 18(8), 663–667. <https://doi.org/10.1111/j.1467-9280.2007.01955.x>
- Wallin, K. G., Alves, J. M., & Wood, R. I. (2015). Anabolic-androgenic steroids and decision making: Probability and effort discounting in male rats. *Psychoneuroendocrinology*, 57, 84–92.
- Wallin, K. G., & Wood, R. I. (2015). Anabolic-androgenic steroids impair set-shifting and reversal learning in male rats. *European Neuropsychopharmacology*, 25, 583–590. <https://doi.org/10.1016/j.euroneuro.2015.01.002>
- Weber, C., Kamber, M., Lentillon-Kaestner, V., Krug, O., & Thevis, M. (2015). Seizures of doping substances at the Swiss Border—A descriptive investigation. *Forensic Science International*, 257, 359–368. <https://doi.org/10.1016/j.forsciint.2015.10.001>
- Weinreb, I., Goldblum, J. R., & Rubin, B. P. (2010). Factitial soft tissue pseudotumor due to injection of anabolic steroids: A report of 3 cases in 2 patients. *Human Pathology*, 41, 452–455.
- Westlye, L. T., Kaufmann, T., Alnæs, D., Hullstein, I. R., & Bjørnebekk, A. (2016). Brain connectivity aberrations in anabolic-androgenic steroid users. *NeuroImage: Clinical*, 13, 62–69.
- Whitfield, M., Reed, H., Chandler, M., Bates, G., & McVeigh, J. (2012). Merseyside & Cheshire Inter-Agency Drug Misuse Database (IAD) needle and syringe programme 2012–13.
- Youssef, M.Y.Z., Alqallaf, A., & Abdella, N. (2011). Anabolic androgenic steroid-induced cardiomyopathy, stroke and peripheral vascular disease. *Case Reports*, 2011.

**How to cite this article:** Mullen C, Whalley BJ, Schifano F, Baker JS. Anabolic androgenic steroid abuse in the United Kingdom: An update. *Br J Pharmacol*. 2020;177:2180–2198.  
<https://doi.org/10.1111/bph.14995>